THE

AMERICAN

SYSTEM OF DENTISTRY.

IN TREATISES BY VARIOUS AUTHORS.

EDITED BY

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THE STOPPING PROCESS WITH GOLD, AND THE RELATED PROCEDURES.

BY LOUIS JACK, D. D. S.

THE stopping process may be defined as any method of treatment of dental caries which effects the removal of the carious matter and substitutes therefor some material possessing such inherent physical properties as render it capable of introduction into all parts of the resultant cavity and of protecting its margins and inner surface from further destructive influences. The most important properties such materials should possess are adaptability, immunity from oxidization at ordinary temperatures, and incapability of solution in the fluids of the mouth.

This process is with propriety divided into two distinct parts—the surgical treatment, and the mechanical treatment.

The first comprises every preliminary effort which has to do with the preparation of any given case for the succeeding mechanical processes, such as the separation of the teeth, the relief of sensibility, the removal of caries, the definition of the boundaries of the healthy structures, the careful and exact formation of the cavity to facilitate the insertion of the stopping and to enable the stopping, of whatever material it may be composed, to be retained. The subjective consideration of the ultimate form of the filling with reference to its usefulness, its appearance, and its relation to the other teeth has also from the beginning of the case to be clearly kept in the mind of the operator. There enters into this branch of the treatment of caries a large amount of knowledge which has been previously stated in this work and a considerable number of general principles, some of which have heretofore been elucidated. Thus the anatomical forms and physiological functions, the pathological conditions which are concomitants of dental caries or which arise as consequences of the carious action, the chemical changes which occur in the tissues, the chemical influences which produce, accelerate, and may retard the progress of caries, the general states of health which influence dental caries, and the special disturbances which have the same power, are conditions which should be so clearly kept in view as to be guiding principles in every exigency which may occur.

The mechanical treatment includes the preparation of the stopping material, the insertion of it, the formation and finishing of the external surface of the inserted material and of the adjacent dental margins in such manner as to ensure the purposes of the stopping. This involves a knowledge of the chemical and physical properties of the materials, a

general knowledge of physics, a correct eye for good forms, a clear judgment, and, moreover, a sensitive and well-trained hand.

These two general procedures, while distinct, are yet so connected that the first bears a constant relation to the second, and the results to be secured by the mechanical process are determined by the judgment displayed during the surgical procedures. At every moment the expert operator is obliged to keep in view the definite purpose of each application of the instruments employed and a clear knowledge of the extent of their action.

Except by the operation here indicated, there is at present no known means of arresting deep caries. The attempt to restore the teeth by these means is extremely direct in its character and so striking in its promise as to have been suggested in the early history of the treatment of caries, the ancients mentioning in their works the use of various substances they employed for the purpose, but making no attempt at permanent treatment so far as we are yet authentically aware.

The success of this procedure has been strikingly manifested for several generations, many fillings having been known to remain intact for long periods of time, varying from ten years to half a century.

Stoppings in carious teeth take the place of lost tissue and are protective of the more highly-organized structures of the tooth simply as the enamel is protective. They also further stop the progress of carious action by excluding débris, sedimentary substances, and the accidental products of the fermentation of these waste matters, and lessen the probabilities of the recurrence of caries at the part by reducing the amount of vulnerable tissue. The operation, hence, is one of positive character, followed by such logical results that the claim that it is a great remedy may be considered to be sufficiently established.

It should be borne in mind that this is an operation very distinct from operations in general surgery in which, where a breach of continuity has occurred or for any reason has been made, the parts are brought into apposition or into a state of rest, and under the influence of natural laws the continuity is re-established and function is restored. Here, on the contrary, a breach effected by the disorganization of tissue is repaired by direct effort: natural restitution of structure being impossible, substances foreign to it are substituted. The new material, under proper limitations, after correct procedures and appropriate therapeutic treatment, arrests the progress of disease at the affected part, and is accepted as a component part of the organ. It should be kept in view, however, that the operation is in its essential nature restorative rather than curative. The consequences of the diseased state of the teeth arising from disordered physical functions or caused by the results of the decomposition of ingesta about the teeth, favored and accelerated by abnormal conditions of the oral secretions, have been simply repaired; but if these conditions remain in force, the carious action may again quickly ensue in the neighborhood of the stopping. This result has proven at all times a serious drawback, and has been inconsiderately used as an evidence of the uncertainty of dental science and as a reproach to dental art.

In some instances comparatively indifferent operations are successful, and in other cases those performed with the greatest care have proven failures. In the former correct physiological function may have become re-established, and in the latter, either from defective hygienic conditions or from chronic impairment of function, the active causes of carious action have continued. Hence the failure of operations on the teeth is not always an evidence of deficient skill, nor, on the other hand, does the success in some instances of indifferent operations give any warrant to the neglect of any precaution for the fulfilment of all the requirements of a thorough operation. But it must be observed of the great number of failures of dental stoppings, many of them occurring in the hands of men of good attainments, that a great proportion of them are occasioned by lack of care in important details or by ignoring some of the requirements of the individual case.

Instances are observed where the patients are subject to recurring periods of disturbed health which may have been overlooked at the time of the treatment. Moreover, the exciting causes of caries may be generally so active, and the inherited predisposition to conditions favoring caries apparently so great, as to render nearly useless the procedure of filling in any manner or by any means other than for palliative and temporary purposes. Further, these causes may be so combined with such local predisposition as softness and other defects of structure as to render permanent treatment of little avail.

All these considerations must be kept in view in forming a correct judgment at the outset of the restorative treatment.

It becomes a question of propriety, when the conditions are unfavorable to enduring operations, what material shall be selected to effect restoration. Notwithstanding that gold is probably better calculated to preserve the margins of the cavity than any other substance if it is placed in close adaptation at all points of the orifice without injuring the enamel, there are frequent serious objections to its use. The time required to introduce stoppings with gold foil is always considerable, and when the teeth are sensitive, soft, and much predisposed to decay, increased time is needed; and, as the filling, of whatever kind, will fail while the above-stated conditions exist, it would appear prudent to reject gold in favor of some temporary substance until a better state of conditions arises. This may follow increase of years or restored health. While in some instances unfavorable conditions may not be capable of control by either patient or operator, they may in many cases be favorably influenced by prudently-directed hygienic observances; therein consists the marked difference between intelligent and thoughtless treatment of the dental organs.

It will be observed from what has just gone before that much more must be considered than merely the manipulative effort. It is apparent that there should be an approximate measurement of the existing disturbed general conditions, qualified by the predisposing tendencies, to enable an intelligent employment of the means at hand to attain the best conservative results.

In the general article upon Dental Caries the consideration of the etiology of dental caries has been fully discussed. The pathology of

the subject, with all the aggravating and qualifying influences, has been elucidated. It has been shown how, when it once commences its ravages upon the dentine, this peculiar and anomalous chemical disorganization proceeds until in the very large majority of instances it destroys the whole of the crown of the affected organ.

It remains here to regard the surgical elements of the disease.

The portions of the teeth most disposed to carious action are those parts where lodgments of sedimentary matters from the ingesta, mixed with waste secretions, such as inspissated mucus and epithelial exuviæ, take place. These situations are those anatomical parts of the teeth which are not subject to the friction of mastication and of the tongue, lips, etc., such as the interstices between the teeth and the declining curve, at the margin of the gum. Of the perfectly-formed teeth, caries is liable to occur in these places in proportion to the activity of the subsidiary influences present; of the imperfectly-formed teeth which have sulci or congenitally-defective spots of enamel, caries occurs in the above-named places earlier, more easily, and runs a more rapid course than the caries of perfectly-formed teeth. They also succumb to a less active degree of the exciting causes of caries. Generally, when such imperfections exist in the enamel, there are also defects of the dentine such as have been denominated interglobular spaces, in addition to which the vital resistance to the chemical reaction is of feebler power.

The period of life when caries is most active is from the eighth to the thirtieth year, when with persons of ordinary health the tendency becomes more or less inactive until senile changes set in, when the teeth may again, from diminution of vital force, be attacked by a form of caries which greatly baffles all attempts of treatment. Similar conditions to those of senility not infrequently occur in middle life, when the secretions become continuously acidulous, and when, also, the dental tissues apparently lose their hardness and their powers of resistance.

When caries manifests itself in the deciduous teeth, as it not uncommonly does, the indications point to its occurrence in the permanent ones very soon after their eruption; and this condition is an evidence of the necessity for the greatest watchfulness and frequent inspection of the teeth. While some indications of the presence of decay may be inferred from external signs, special and thorough examination of all parts of the teeth is a necessity to determine their condition in this respect.

Instruments of General Use in the Various Procedures, and the Mode of Employing them.

The mouth-mirrors represented in Figs. 1 and 2 are a constant aid for reflecting light and for conveying to the eye an image of parts inaccessible to direct vision.

The mirror shown in Fig. 3 is intended for holding the cheek away from operations on the buccal surfaces and for maintaining illumination of the contiguous parts.

It is necessary to have mirrors both plane and slightly concave. If the concavity be considerable, the definition becomes so indistinct that

more is lost in this manner than is gained by the enlargement of the image. If it is desired to enlarge the image, this is best done by a magnifying-glass, more particularly by the watchmaker's eye-glass. For purposes of illumination the concave mirror is best suited because

Fig. 1.

Fig. 2.

Fig. 3.

of the greater condensation of the rays of light, while for the reflected image the plane mirror is preferable, since the image is by it more clearly defined than by the concave one.

These mirrors should be capable of making a clear image, and to do

Fig. 4.

Fig. 5.

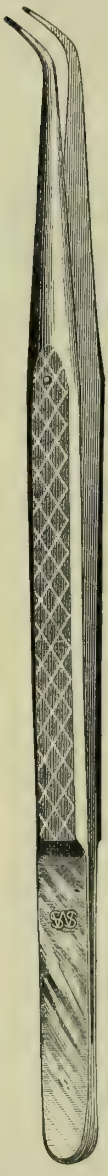


Fig. 6.

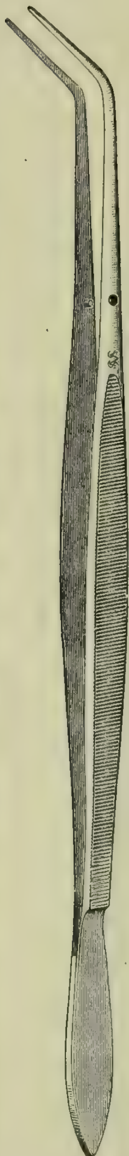


Fig. 7.

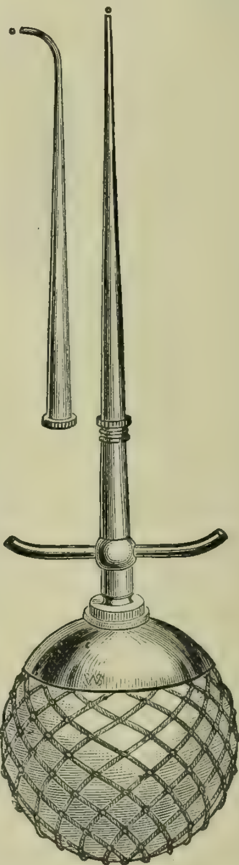
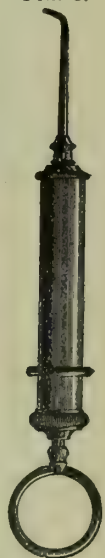


Fig. 8.



this should be of the best quality. Those made by a deposit upon the glass of pure silver protected by a coating of copper are much better than the ordinary ones, as they are clearer and of greater durability.

The fullest advantages of the mirror are secured only by those who acquire the facility of working to the image. By this method the most obscure places are brought into full view of the eye, and after practice the facility of operating entirely to the image becomes much easier than

the attempt to operate by direct vision, even when the parts are illuminated. The mind soon learns unconsciously to direct the movements of the hand in reverse, which then take place with dexterity and precision. There are in this certain advantages which may be enumerated. The attitude of the body may be more erect, the head is out of the line of illumination, the mouth of the patient need not be painfully extended, and the speed and facility of operating is enhanced. To avoid the obstruction of reflection by deposition of moisture upon the glass, the mirror should be somewhat warmed; but when the rubber dam is in use, the necessity for this is lessened.

Pliers.—Fig. 4 shows Dr. Perry's annealing pliers. These have

Fig. 9.

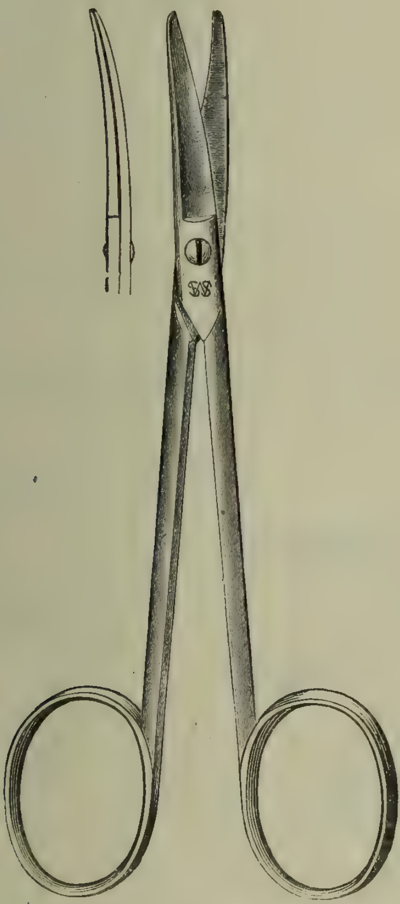
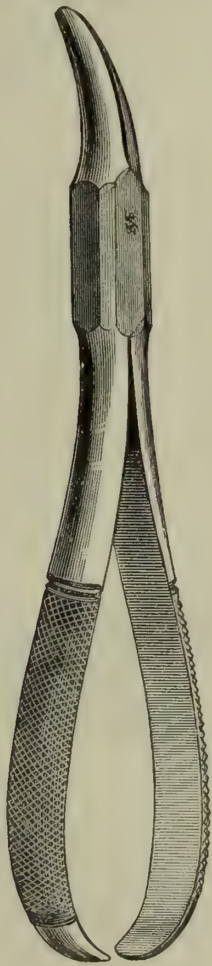


Fig. 10.



varied uses, and on account of their delicacy are of service in applying drying-papers, making medicinal applications, conveying gold to fillings, etc.

Fig. 5—called "college-pliers"—are applicable for similar purposes, but, being heavier, are also useful for withdrawing ligatures and wedges, and for inserting large pieces of gold during the filling process.

Fig. 6 shows Dr. Flagg's dressing-pliers, more especially useful for making medicinal applications at distal surfaces and deep-seated parts.

Figs. 7 and 8 show water-syringes. These should be of two forms —one to deliver a small stream with considerable force, the other with a large opening, to deliver a large volume of water with less force—the former for the removal of small quantities of débris, for cleaning pulp-chambers, etc.; the latter where large amounts of débris require displacement or for the washing away of blood. As this instrument is in constant use, it is important that it be of satisfactory quality. The Fig. 8, made by Codman & Shurtleff, is of even working capacity, of proper length and size, and of enduring quality.

The air-syringe or chip-blower is employed to clean out the cuttings from the cavity during the process of preparing it when protected by rubber dam. For this method, which is suitable only during the general process of preparation, should be substituted the water-syringe at the final cleansing, since the air-syringe may fail to remove all of the finer particles, any one of which, remaining at a margin, may injure the quality of the filling.

Fig. 9 shows the curved scissors which are used for cutting away parts of gum tissue, severing ligatures, relieving rubber dam at the moment of its removal, and other continually-occurring uses.

Fig. 10 shows the wedge-pliers of Dr. Palmer, which are used for the insertion and removal of wedges and the withdrawal of tightly-impacted ligatures.

Fig. 11 represents the beaks of Dr. Miller's wedge-cutting pliers. Their use is for cutting off wedges inserted to separate the teeth or to

FIG. 11.

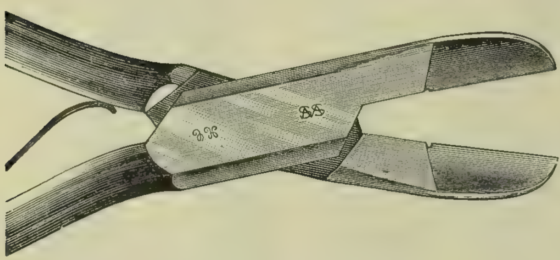
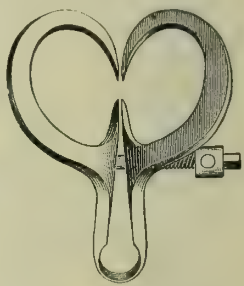


FIG. 12.



retain spaces already made and to sever the wedges used to fix matrices. They have surfaces for compressing the wood.

Fig. 12 represents one form of the Perry separator, which is an improvement of the Jarvis separator. The uses of this form are for making temporary spaces for the purposes of inspection of doubtful interstices, and where the teeth easily open they often have a wide range of use during the packing and finishing of stoppings.

Fig. 13 represents one applied.

Fig. 14 represents an improved shape of the former, also by Dr. Perry, which is better fitted for the extension of larger spaces than the former is adapted to make. Since they contain two screws, the pressure may be brought to bear equally upon the teeth, and therefore the force of the screws may be expended to greater advantage upon the teeth. Fig. 15 shows one as applied to use. The teeth are pressed apart

Fig. 13.

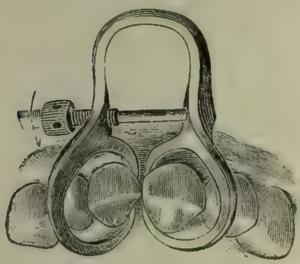


Fig. 14.

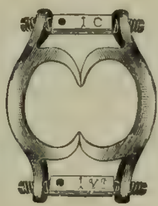
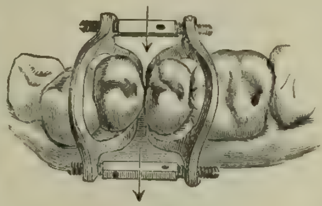


Fig. 15.



by turning the screws in the direction of the arrow marked upon the bars. If the teeth are not too firmly fixed, they readily yield to the force applied. As the patient becomes accustomed to the pressure, the force may be reapplied and the space increased. At first the instrument appears inconvenient and harsh, but facility of employment is quickly secured by practice, and then it is found more acceptable to very many persons than the plan of separating by wedges. This appliance may in many instances be retained on the tooth during the operation, and on account of the many advantages attending its use it is an adjunct of great value. Even where it may be found necessary to separate the teeth by pressure this instrument may be used to increase the space made by other means, which space may then be secured by a wooden wedge. After the insertion of proximate fillings by the contour system the gold frequently may be in such close contact as to preclude finishing without cutting it away, which is usually not allowable. In such cases the separator may be put on during the finishing processes. It will be observed that the bar is shorter and the bows are made to converge on the inside, to adapt this end of the appliance to the smaller

Fig. 16.

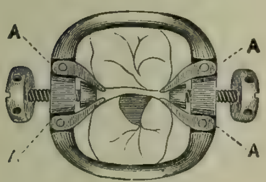
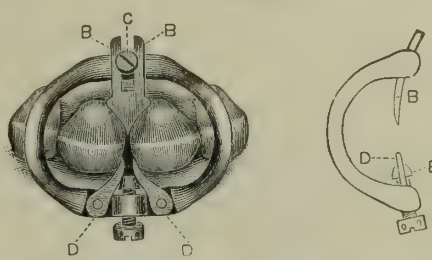


Fig. 17.

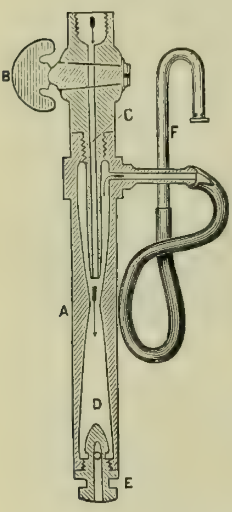


circle of the interior of the arch. For similar purposes Dr. Woodward has invented a separator which has some points of great superiority. This is shown in Fig. 17.[1]

[1] See *Dental Cosmos*, vol. xxviii. p. 285.

Ejection of Saliva.—The *saliva-ejector of Fisk* (Fig. 18) may be advantageously employed to evacuate the mouth of saliva. It is of use as a means of relief to the patient as well as an aid to the operator, and should be used at any moment when it appears advisable. For this purpose the most advantageous connection is with the fountain-spittoon, which supplies all the necessary facilities for the attachment of this appliance and allows it to be cleansed during the intervals of use. By the aid of the ejector many cavities may be filled without any complicated means to keep away the saliva. Fig. 19 shows the fountain-spittoon with the saliva-ejector.

Fig. 18.



Where abundance of water is not available, the ejector of Dr. Snow (Fig. 20) may be applied. This requires but a small amount of water, but it is liable to the objection that no means are provided thoroughly to cleanse the tubes. The absence of this facility renders this instrument objectionable to fastidious persons. There is hardly any town of large size, however, where the first-mentioned admirable device cannot be adopted.

This means of disposing of the saliva when required, and of maintaining the cleanliness of the cuspador, are indispensable adjuncts in this practical age. Attachments are now made to dental chairs which meet all the above-mentioned requirements.

Rubber Dam and its Auxiliary Appliances.—The invention by Dr. Barnum of the application of rubber dam to protect teeth from moisture while being operated upon is an essential and marked step in the new era of dental surgery. Without it the greatest skill is powerless to secure sound results in many large and complicated cases; with it there is no impediment by encroachment of saliva to carrying out fully the subjective idea of the operator. Therefore, since the introduction of rubber dam, operations are executed with gold which before were impossible.

A marked benefit of the use of rubber dam is that it liberates the left hand of the operator and permits it to assist the right in various ways during the packing of the gold, the advantage being fully equivalent, in many instances, to the aid of an assistant.

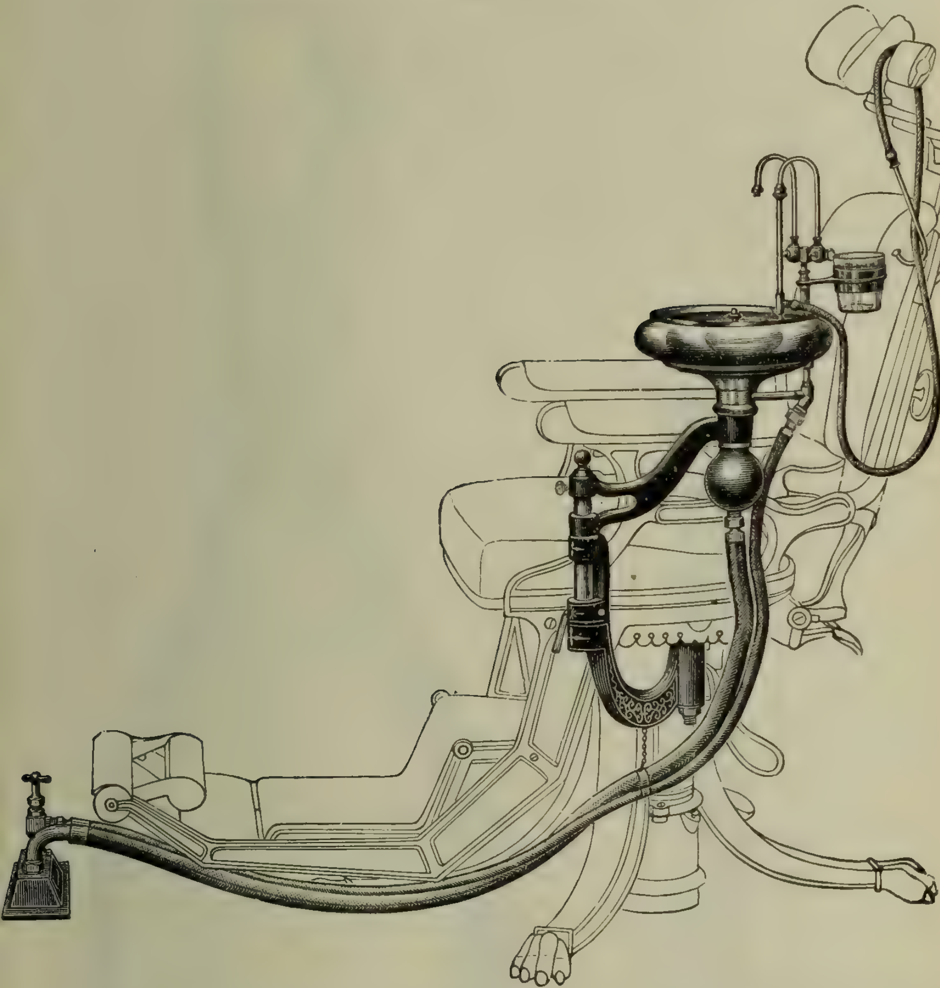
Satisfactory application of the dam depends much upon its quality. It should be of light color, but not the lightest, soft and kidlike to the touch, and exceedingly pliable, and on extension should freely yield to the thumb when forcibly pressed into it, and should completely return on the withdrawal of the pressure. If it has these qualities, it will not tear if fairly applied.

The thickness best adapted to average cases is the medium for the back teeth, and the thin medium for the front ones.

Some establishments furnish this material in long rolls, which should be not less than 7 nor more than 8 inches wide. The shape of the

piece, providing it be sufficiently large, is not material. Many use parallelograms 6 by 8 inches. But an excellent and generally better form is a triangular one which can be varied in size from small for the

FIG. 19.



front to large for the back teeth by cutting it at pleasure from a roll 8 inches in width.

After a suitable piece is cut it is punctured with holes at proper places, to permit the teeth to pass through. These openings must be so far from the margin that there may be no danger of moisture finding its way over the edge, and they must also be situated so near the margin as to prevent a cumbrous amount of rubber above the lip, to the annoyance of the patient. They have to be at such distances apart as to leave a complete strait of rubber between the various teeth, to make them water-tight, and yet, at the same time, there must

be no excess, to produce folds of rubber there. The size of the holes is varied with the dimensions of the teeth. In general, the first or smallest hole of the punch is adapted to small laterals and the inferior incisor teeth; the second hole, to centrals, cuspids, and bicuspids; the third size, to the molars; and the fourth, to the molars when the dam is to be passed over a clamp.

The distance between the holes is also to be varied with the size of the teeth, since, where they are large, more of the strait between

Fig. 21.

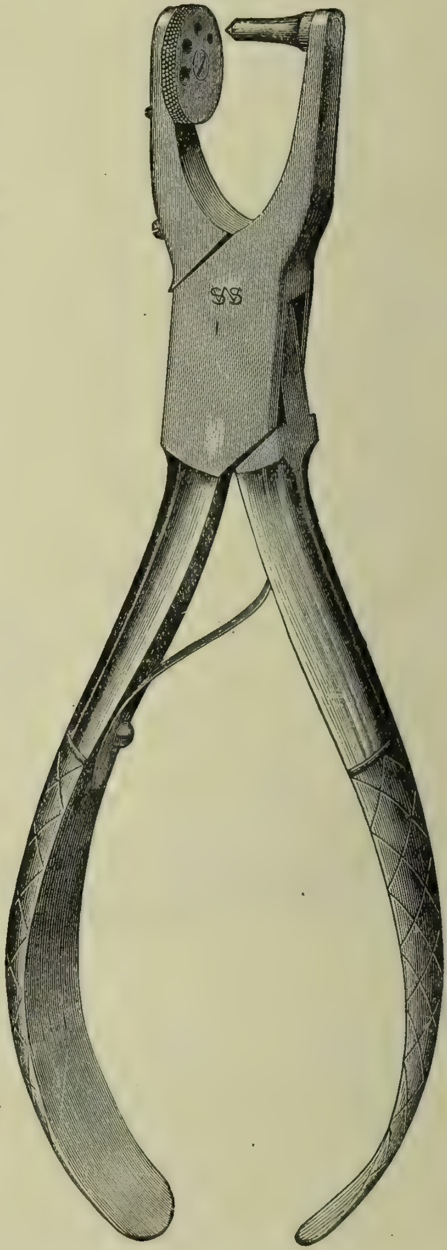
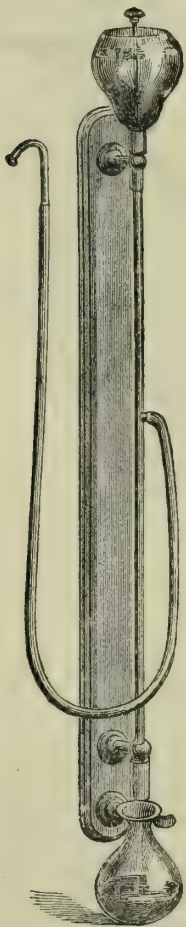


Fig. 20.



the holes is taken up in the extension of the rubber. The distance

between the teeth also controls the distance between the holes, since the space is to be freely covered; also, if the rubber must be forced downward to be extended below a cavity which has its cervical border beneath the gum, allowance must be made for this also. Generally, in ordinary cases, when the teeth are near together and the gums firm, an eighth of an inch is the proper distance between the holes to prevent laceration of the rubber in forcing it over the molar teeth, and, on the other hand, to secure tightness on its being placed over the smaller teeth. The number of holes should be sufficient to give full access to the case and permit the free entrance and reflection of light, and for this reason it is better to have several teeth extend through the rubber even for simple cases, unless there be the serious impediment of too great a closeness of the teeth. Thus, for a proximate cavity of a central incisor, at least four teeth should be included, but better six; for the mesial of the first molar, this and both bicuspids. In case the teeth are easily ligatured, another additional tooth included is an advantage.

The accompanying cut (Fig. 21) represents Ainsworth's rubber-dam punch, which has a series of perforations of graded sizes on a disk which is revolved beneath a cone-shaped punch. The hole is made by the impingement of the punch upon the sharp angles of the perforations. The holes made in the rubber by this instrument are far superior to those formed by the cylindrical punch, as the latter soon becomes unserviceable and ceases to cut a clear hole. The importance of this is marked, since upon the exactness of the orifice in the dam depends its sure passage over the teeth and through the tight spaces.

Fig. 22 shows a piece of rubber pierced for the central incisors, the figures representing inches.

Fig. 23 represents a piece of rubber pierced for the upper molars. It will be observed the line of the holes is not parallel to the upper edge.

Fig. 24 shows a piece of rubber for the lower molars.

Fig. 25 shows the arrangement of holes for the lower incisors.

FIG. 22.

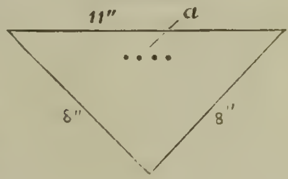


FIG. 23.

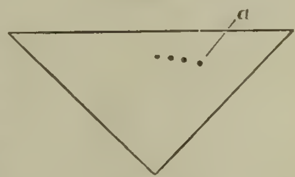


FIG. 24.

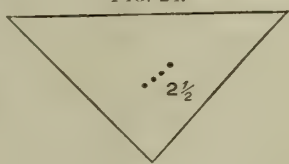
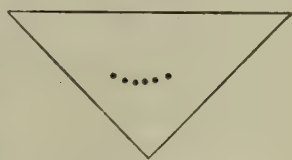


FIG. 25.



The application of rubber dam where the teeth are somewhat apart or when they are flexibly attached is simple. For instance, as represented at Fig. 24, for the left lower teeth, the rubber is seized with the index-fingers on the upper side, the thumbs beneath, and grasped near the hole to be applied over the first bicuspid. The hole is extended in size; the edge of the rubber is inserted in the interstice and carried down to the gum. It is next carried over the tooth and passed into the next inter-

stice in the same manner. This method is applied to all the teeth in succession intended to be included. The passage of the rubber may be greatly facilitated by an assistant helping it downward by a piece of floss-silk held tightly and drawn between the teeth by a careful downward-and-sliding movement of the silk, which should be well waxed.

When the teeth are firm and in close contact, it is often somewhat difficult to make an entrance of the rubber between the teeth. The interstices should be silked, to clear them ; and if any impediment offers, a band-saw or a thin Kaeber saw should be passed through. In many instances a little bennie oil put on the silk will sufficiently lubricate the tight places. An excellent formula for this purpose and as a dressing to the lips and mouth of the patient when these parts are feverish, or where there is a tendency to herpes labialis, in which bennie oil is the essential ingredient, is as follows:

℞.—Ol sessamii, ℥jss
Glycerina, ℥j
Mel desp, ℥ss
Cosmoline, q. s.
Ol. rosa, gttj. M.

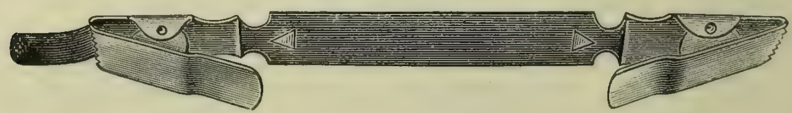
The spaces may be wedged successively by forcing a wedge in at the neck. When spaces have been made by pressure, as is generally required for proximate cases, the adjoining teeth will usually yield enough by very slight wedging; and when it appears necessary, a small starting-space may be made by previous pressure. This can be taken up at each interstice when there may be too great closeness of the other spaces.

In some instances it is necessary to put a clamp on the distal tooth and pass the rubber over this and the tooth. This is required when the teeth are short or badly shaped for holding the rubber. The starting-point should then be at the clamped tooth, but generally it is more convenient to commence applying the dam to the forward tooth and proceed backward.

Another method of overcoming the difficulty of management is to pass the arch of the clamp through the hole in the rubber. When the clamp is placed on the tooth by the forceps, the rubber is partially extended, and is then drawn over the jaws of the clamp and adjusted beneath them.

When this step has been accomplished, the rubber should be conveyed to the necks of the teeth by passing waxed floss-silk down the face of each tooth; and when required, the ligature may be tied around the tooth. This is done for the following reasons: to carry the

Fig. 26.



rubber farther down beneath the margin of the gum in proximate cavities, to prevent the rubber from rising, and to make a more secure closure of the valve. To ligate the teeth for this purpose, the silk

should usually be passed but once around the tooth and tied by a surgeon's knot, the place of the knot being on the outside of the tooth. When there is much strain upon the rubber, the thread should be passed twice around the tooth. To induce the rubber to descend upon the tooth, it is usually not necessary to force the thread downward with instruments, as is too commonly done, to the pain of the patient. If the silk be passed around the tooth near the neck, the free ends crossed and drawn with a slight sliding movement around the tooth, the ligature will descend the inclined form of the cervix and carry the rubber along with it.

Fig. 27.

To open the case to access and the light, the rubber is held aside at either upper corner by dam-holders, of which there are various forms, none, on the whole, being so convenient as the one represented at Fig. 26. In addition, a supporter is often required to prevent the holder from falling downward. Fig. 27 shows Dr. Peck's supporter. This passes over the head, the hook on each end engaging with the holder, and is adjusted by the sliding end. At the same time a small napkin should be included at either catch, to prevent disagreeable clamminess upon the patient's face. The excess of rubber at either side may then be taken up by a fold and fixed by dressing-pins to the napkin, near the catch of the holder. Arranged in this manner, the case is placed within easy access.

As the patient is often kept under the restraint of this arrangement for a long time, every comfort should be afforded by placing a dry napkin beneath the other when necessary, by laying a fold of soft paper over the upper lip, and notably by evacuating the mouth of saliva when the flow is excessive or there be any difficulty of swallowing. Fig. 28 represents the dam and the appliances in place.

The application of the dam by persons of experience is nearly as quickly made as the adjustment of napkins and the ordinary inefficient means of excluding moisture, and is infinitely more agreeable to the patient in the cases requiring considerable time. Much needless irritation, however, is frequently inflicted by rough and forcible application of the ligatures, which should be sedulously avoided. For many simple cases, such as the coronal surfaces of the upper back teeth, there is no necessity whatever for using the dam unless every opportunity exists for its prompt application.

In some instances the attempt to introduce the rubber is attended by nausea. This may be remedied in most cases, and ameliorated in all, by the gargling of the mouth with camphor-water or spirits of camphor painted upon the sensitive parts of the palate or tongue.

The dam is usually not applied until after the preparation of the cavity for the filling process, but there are many cases when it is advantageous to do so at the early stages of the case. The cavity should be defined and the softer caries ordinarily removed, but in deep and precarious ones only the definition should be made. The cavity can then be prepared with more ease and with less pain by putting on the dam at these stages.

At times it becomes necessary to completely clear out the débris during the preparation; and when the rubber is in place, this is done by washing out the cavity and withdrawing the water—by the saliva-ejector when the case is of the lower teeth; or the bulk of it may be taken up by soft bibulous-paper, the latter method being used for the upper teeth. This mode of cleaning the cavity is indispensable immediately before commencing to introduce the filling, since no mode of wiping or blowing out the débris completely cleanses it. When the case is a proximate one, it is scarcely possible properly to prepare the cervical border and the tooth above this point without mangling the rubber, it then becoming necessary to remove it and put on a new piece.

One of the great advantages of preparing proximate cavities while having the dam applied at the time is that the least defect of the margins becomes perceptible, as, if the parts are occasionally air-dried, the least loss of integrity of the enamel is indicated by the appearance of a white opacity. Under ordinary methods, frequently, such a place would escape detection. These spots also appear more distinctly after the margins are polished at the final step of the preparation.

In reference, however, to applying the dam to prepare cavities, some

FIG. 28.

discrimination is required to protect the patient from unnecessary annoyance.

Various little appliances are employed to aid in adjusting the dam—notably, small weights to hold the lower free edge down, and overdraw

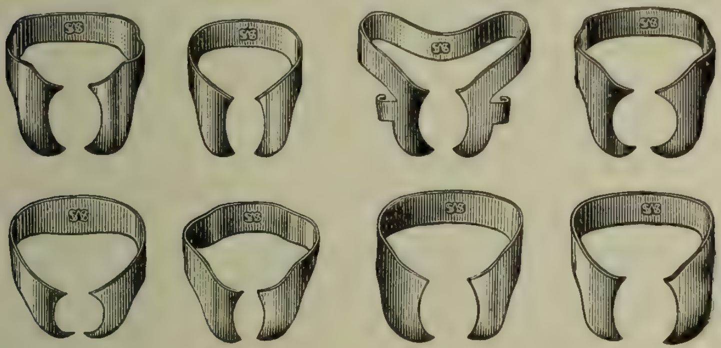
weights to hold the upper edge from falling. These and the arrangement of the dam are shown in Fig. 28.

Clamps, and their Application.—Clamps are also used to prevent the rubber from being forced off the tooth by the muscular contractions of the lips and of the tongue, to assist in forcing the rubber higher up on the tooth, and, in the posterior teeth, to press the rubber somewhat aside to improve access to the cavity. The clamps, however, should not be used in the anterior teeth unless absolutely necessary, properly-applied ligatures generally being sufficient.

The clamp should be selected to impinge nearly equally upon all parts of the tooth embraced. It should be without serrations on the edge, and should not rest upon the acute points found on some of the forms, as there are instances of the soft teeth of children being injured by abrasion of the enamel caused by the riding of these points upon them.

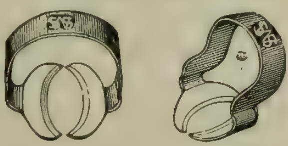
Fig. 29 represents Palmer's set of eight, which are all well adapted.

FIG. 29.



In addition to these, Huey's wisdom-tooth clamp and Southwick's modification of it (Fig. 30) and Moore's set of four (Fig. 31) will cover nearly every want for the back teeth. These are applied to the teeth by means of clamp-forceps. Properly to apply a clamp, it should be carried over the tooth about midway, when the inner beak should be pressed down to the gum, and, with this resting somewhat as a fulcrum, the outer beak is carried to its place, near or to the gum. This orderly movement avoids the disagreeable slips of the clamp if it does not at first embrace the tooth at the restricted part, near the gum. When there is danger of the clamp pressing with too much force upon the gum, the tooth should previously be ligated, which checks the pressure.

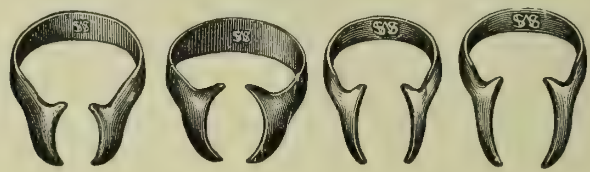
FIG. 30.



In some instances, after the completion of the packing in proximate cases, the finishing of the cervical portion of the filling may be done while the rubber is retained, since it protects the sides of the mouth and the lip from the friction of the paper disks and the tapes. When it is

desired to remove the dam, all the accessories are taken away; the ligatures are cut with a sickle and removed. If the spaces are open, the rubber is withdrawn upward; but in case the spaces are closed it is

Fig. 31.



preferable to pull the free edge of the rubber outward and cut the straits between the teeth, when the whole can be in an instant taken away.

Dental Engines.—The invention and introduction of the so-called dental engine is one of the remarkable features of the new era in dental surgery which was ushered in by the intelligent introduction of the use of cohesive gold by Dr. Arthur. It may truly be stated that the initial movement of the modern school of dentistry commenced with the use of cohesive gold, which received an immense impulse by several nearly coincident advance steps—viz., the introduction of percussion in packing gold, the invention and application of rubber dam by Barnum, and of the dental engine by Dr. Morrison. These several movements combined have given dental surgery such an impulse as it had not received in the previous century. They have substituted precise and scientific methods for the old and uncertain ones.

The first inventions in the direction of speeded instruments for dental purposes, when the power was not dependent upon the hand, were made by B. F. Green, a machinist, of Michigan, who devised an electrical rotary engine, a pneumatic engine, and an electrical mallet. Neither of his inventions was devoid of objections, as was to be expected in the inception of efforts in so new a field, but what he did gave an impulse in this direction which led Dr. Morrison to invent an efficient implement which in the hands of Messrs. Johnson of New York became nearly unobjectionable in its working capacity.

The next decided step was the attachment of the flexible shaft of Snow to the pulley-standard of the White engine, which was then, and is now, an exceedingly simple instrument. It has, however, the serious disadvantage that the rotation of the cable within the sleeve produces some vibration of the hand-piece, these slight movements preventing the steady cutting of the engine-bit, the rotation being necessarily accompanied by some chattering of the tool. This is partially remedied by the intervention between the cable and the hand-piece of the flexible spring of the improved Morrison engine.

The vibration noticed above is a serious detriment, since it impairs precision of action, lessens efficiency, and adds greatly to the discomfort of the patient. It also prevents the instrument from being employed with the lightness of touch necessary to the performance of many delicate operations. The highest efficiency of the dental engine is secured

by lightness of touch combined with high motion, and to have the former the hand of the operator must be unembarrassed by any adventitious movements or by the employment of inhibitive efforts.

During the period of experimentation and improvement of the Morrison engine by the Johnson Bros. and of Dr. White's modifications, Dr. Bonwill carried on a series of ingenious improvements of the Morrison engine, during which it has steadily gained in efficiency, until it is now nearly free of objectionable features. The hand-piece is simple and efficient in its working capacity, and is so completely disassociated from the vibrations of the other parts of the apparatus that it runs with extreme lightness and steadiness, and is, therefore, far superior to other similar appliances. The result of these advantages is greater rapidity of the cutting and much lessened discomfort and pain to the patient.

Second to the liberation of the hand from the vibrations of the dental engine is the character of the hand-piece. The present tendency is toward those of simple modes of working in which the bit is grasped by some form of universal chuck operated by automatic devices. This feature secures the sure centring of the instruments, and therefore adds to the element of precision. All these qualities are embraced in the Bonwill hand-piece. A not-insignificant result of the absence of vibration in Dr. Bonwill's instrument is the greater durability of the points.

The forms of these instruments are so familiar through advertisement that it is unnecessary to encumber these pages with representations of them.[1]

The number of forms of instruments to be used in the dental engine is very considerable, and the advantage of their use is almost inexpressible. They need, however, to be of the best quality, and should be discarded when they become the least dulled. They should be so sharp that they will do their work without recognition of the employment of force while using them; and when of good quality, the hand is simply engaged in directing the instrument. The sensations of the finger will then determine when the instrument has reached the limits of the diseased bone. When employed for the cutting of definite forms at any given point, a few revolutions are sufficient to make the necessary changes of shape, it being understood as a preliminary condition that the hand-piece and engine are not vibratory.

The dental engine is not, however, well adapted to cut the enamel. When this structure is dense, it does not yield; the friction excites heat and dulls the burrs without a compensating result. The same difficulty is less observed in the cutting of dense dentine. When the instruments are properly selected and are in good condition, if due regard has been paid to the means of reducing the sensibility, the engine cuts with a surprising degree of comfort to both patient and operator. If the bits are sharp and rapidly revolved, the pain is much lessened. On the other hand, the attempt to use dull burrs with force is an atrocious outrage. It is on account of disregard of the most obvious mechanical and physical principles that harm has been inflicted with the dental engine.

[1] For the chronological development of this class of instruments, commencing with the modified bow-drill of about 1846, the reader is referred to the *History of Dental and Oral Science in America*, by James E. Dexter, pp. 116–120.

It should be stated that novices should use the dental engine for anything but marginal work with great caution, since by the least carelessness too much dentine may be removed or the pulp may be unnecessarily denuded. In all cases when it appears imperative to use force some other instrument—such as the chisel, gouge, or bone-cutter—is required.

The most useful forms of the engine "bits" are the fissure, the inverted cone, the wheel, the oval, and the round.

Fig. 32 shows the fissure-burr, which is used for opening and following the course of sulci; for making retaining-pits, when the end alone is used; for forming retaining-grooves, when the side is employed; and for opening into pulp-chambers of devitalized teeth. For this latter purpose the end should be ground down at two sides, to produce a wedge-shaped point, the teeth at the sides keeping a free course for the point in its progress. It may also be used to make separations between the teeth and to separate the roots of teeth difficult of extraction, to enable them to be removed *seriatim.*

Fig. 32.

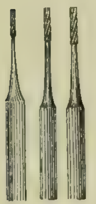


Fig. 33 shows the inverted cone. All sizes of these are useful for slightly undercutting the orifice of cavities of easy approach at the last stages of their formation.

Fig. 34 shows the form of the wheel-burr, which is used for cutting down the enamel margins of shallow cavities—more particularly on buccal and labial surfaces—and for the formation of retaining-grooves within the margins of cavities, particularly of the proximate surfaces of the incisor teeth. The smaller ones are very useful in all stages of the preparation of minute cavities of the front teeth.

Fig. 33.

Fig. 34.

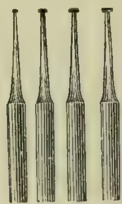


Fig. 35.

Fig. 35 represents the oval burr. The smaller ones have but limited use. The larger ones are useful to cut retaining-grooves at the base of the enamel in the large coronal cavities; beyond this their range of use is meagre.

Fig. 36 represents the round burr. This shape has probably the widest range of use of any of the forms of the speeded drills. It may be employed in all classes of cavities from the opening to the finishing processes. Its form permits a greater latitude of movement of the shaft of the instrument than any of the other shapes, and allows it to follow the course of the carious action. The resultant form of the cavity permits the filling material to be forced into all parts of the cavity, which is liable to be otherwise when the shape of the instruments is angular. The majority of cavities may be prepared with this instrument, except the definition of the margins where the enamel is hard.

Fig. 36.

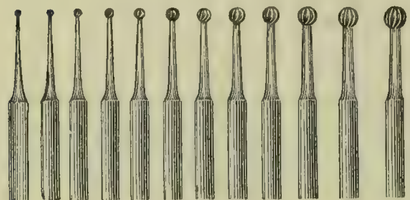
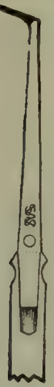


Fig. 37.



Another excellent use for the round burr is to prepare retaining-grooves in the enamel during the formation of proximate cavities of molars and bicuspids. After the grooves have been started in the bone the drill is inserted in the groove, when the cutting is made by the teeth near the shaft of the tool during a coincident withdrawing movement.

Fig. 38.

Fig. 39.

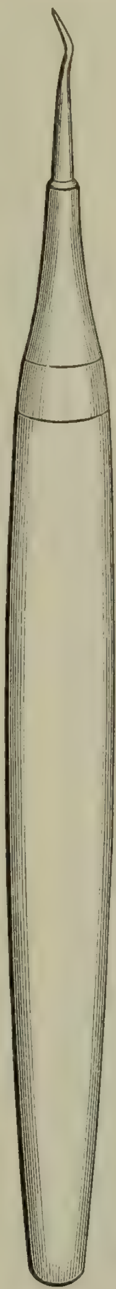
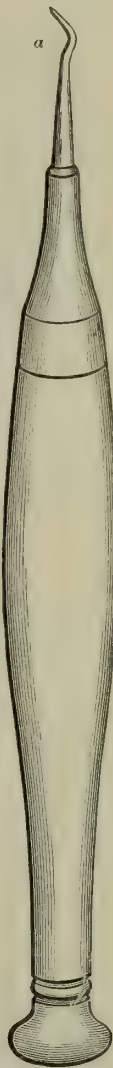


Fig. 40.



Handles and Points.—The subject of the form and the proportions of the handles of instruments to their points is of some importance, since correct relations of these parts increase the efficiency of the points and convey to the mind indications through feeling and sound, which badly-balanced instruments frequently fail to do. The working portion is called the blade; the next part, which may be either straight or curved, is the shaft; the remainder is the handle.

Instruments used for excavating where the blades are usually small and thin and where delicacy of touch is necessary are better made of one piece of steel, and to produce the proper balance and vibration the handles should be tapered. The same considerations are of importance when applied to packing-instruments which are to be malleted. The size of such instruments' handles should be graded to the size of the point and the weight of the mallet to be used.

For chisels, grooving-instruments, hand-pluggers, and burnishers some form of socket-instruments is generally more serviceable. The handles of these have to be large, to give the required leverage to enable rotative force to be

exerted and to permit inhibitive force to be exercised without interfering with the general action of the instrument. The form of socket best adapted for such instruments is the Salmon socket. This is not liable to the serious objection of the instrument turning in the socket, which is inseparable from those which are screwed in, and which render uncertain every movement requiring force. This is particularly the case with all forms of instruments fastened in this latter way which have to be used by lateral movements.

The form of the Salmon socket is shown at Fig. 37. This may be made in the larger instruments where the handles are large. The size of these socket-handles should vary from those for the small chisels and groove-cutters of five-twelfths of an inch in diameter to those for burnishers, which may be eight-twelfths of an inch in diameter. Those for hand-pressure packing should be a full half inch in diameter.

Fig. 38 represents excellent forms for heavy chisel-handles. These are flat and have the corners rounded.

Fig. 39 shows those for hand-packers.

It will be observed that the latter have a concave curve (*a*), which adapts them to avoid making abrasions or pressure upon the mouth. When used for chisels, the second finger rests in this curve. These instruments are made round, to permit the smallest rotation to be made without the natural interference which polygonal sides offer to slight rotative movements.

Fig. 40 represents the handles of burnishers. As these are generally permanent instruments, the points may be fastened in with melted shellac, which permits the removal for alterations or repairs without the necessity for interference with the handle.

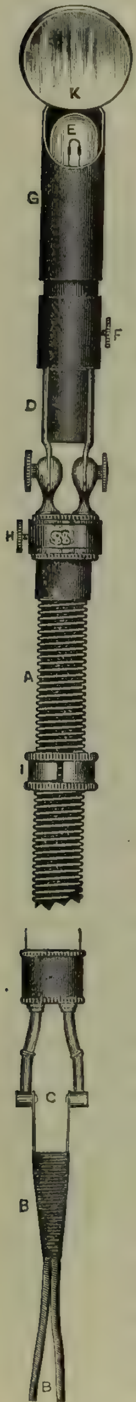
Examination of the Teeth.

The importance of a careful examination of the teeth and mouth preparatory to the treatment of dental caries can hardly be overestimated, as on it depends the formation of a correct plan of the treatment required.

To aid in placing the results of a thorough examination before the mind, it has become the general practice to record them upon suitable charts in a book for the purpose—a course which is so satisfactory as to be indispensable. This record is easily made to include all the possible needs of any given mouth by the adoption of symbols which will indicate all the different conditions and the operations required.

It is important that examinations be conducted in a thorough manner, as the consequences of carelessness are frequently of a serious nature, since carious places may thus be overlooked which before the next inspection might be the occasion of serious injury. To enforce the habit of careful and exhaustive inspection, an arrangement of allotted time should be made for the purpose. Not only should the extent and character of the decay of the teeth be noted, but a number of qualifying conditions should be known concerning them, such as the structural quality, the number which have been lost by caries, the period when they were lost, the physical appearance of the fluids of the mouth, the general chemical reaction of the oral secretions, the state of the mucous membrane of the

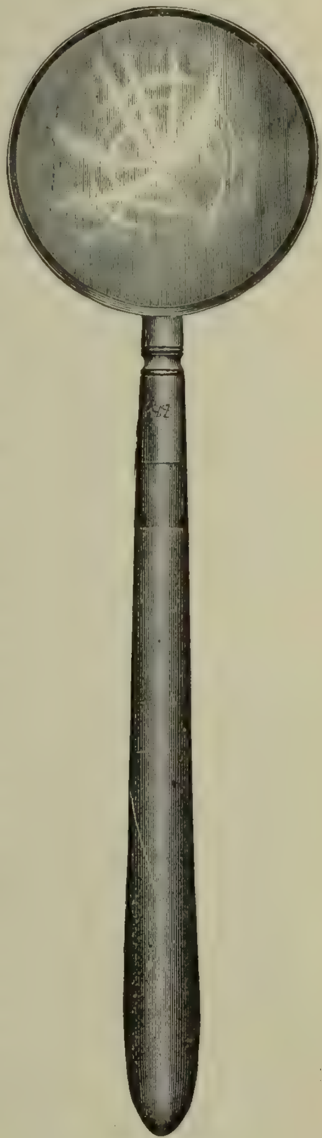
FIG. 41.



mouth and throat, the condition of the gastric functions, the dietetic habits, the general hygienic surroundings, the state of the patient's general health, and the hereditary constitutional tendencies.

There are several general conditions which are of considerable importance in their relation to the state of the secretions of the mouth. These are the tendency to tubercular affections, the gouty and the rheumatic diatheses, and probably that form of malaise so prevalent in many parts of our country as an expression of malarial influence. All of these are significant of dental disorders. They are each accompanied by gastric or alimentary disturbances. The former has associated with it an underlying lowness of physical tone, whereby the nutritive functions are subject to frequent depression and functional impairment. The gouty and the rheumatic are essentially disorders of nutrition which in one case may have inherited influence upon digestive conditions in early life. The congestions and disturbances of the malarial influences pertain more particularly to the abdominal viscera.

FIG. 42.



Unless these factors, which underlie and qualify dental caries, are considered, the treatment will frequently fail of its intended purpose. Permanent operations may be attempted when temporary ones for a few years would be more suitable. Attempts may be made to save all the teeth where judgment enlightened by a consideration of all the qualifying elements of the case would by the removal of some make it easy to preserve the remainder where without this sacrifice the permanent preservation of any would be doubtful. On a knowledge of these conditions

also depends correct hygienic advice whereby much future disturbance may be prevented.

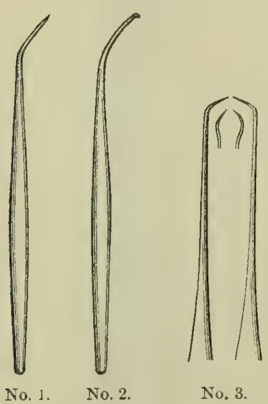
The special examination of the teeth to determine the number, position, and extent of the carious cavities in them requires several instruments and appliances—viz. mirrors, magnifying-glasses, explorers, floss-silk, and wedges.

The mirrors should be both plane and concave, their purpose being to illuminate the teeth under inspection and to assist in revealing by reflection the presence of cavities or of suspected defects.

For the illumination of the mouth and teeth the incandescent electrical lamp has recently come into use, by which it is claimed that the condition of the teeth can be more certainly determined than by the ordinary means. It is, however, questionable whether this instrument is of much service except for determining cases of doubtful vitality of the pulps of teeth and the presence of incipient caries where it has not as yet resulted in disintegration of the tissues. (Fig. 41 shows this instrument.) The current may be supplied by two or three cells of a Bunsen or a small bichromate battery. It is regulated by a resistance-coil in the handle, which facilitates ready adjustment of the current. A serious disadvantage is the amount of heat generated, which requires repeated cooling of the instrument.

Magnifying-glasses of 4 diameters mounted like watchmaker's glasses or in form as shown in Fig. 42 are of service in detecting small fissures and minute defects which escape detection by probes and the ordinary means of examination, but are thus plainly revealed. These glasses are indispensable in making examinations of cavities immediately previous to the introduction of gold, and to inspect the margins of fillings after their insertion to determine whether there may not be deficiencies. The late Dr. Elisha Townsend was unremitting in the employment of this glass, and much of the perfection of his work was due to the extreme precision which close inspection in this manner gave him.

FIG. 43.



No. 1. No. 2. No. 3.

The explorers are intended to be introduced in the fissures which may be detected, and to be applied between the teeth and to all points where caries is likely to occur. The points should be of steel and the handle of metal, the reason for this qualification being that much depends upon the notice of the slightest vibrations, which might be frequently lost if a wooden or an ivory handle should intervene between the hand and the instrument. The requisite forms of the instruments for this purpose are few and simple, the great number figured on the catalogues being wholly unnecessary. The following shapes will cover all the necessities which ever arise: No. 1 is for the detection of defects in coronal, buccal, and lingual surfaces. No. 2 is the most useful form for the exploration of the proximate surfaces of molars and bicuspids. It is

planned to enable the point to detect the inequalities which form when caries in an incipient condition between the above-named teeth has advanced so far as to have caused slight disintegration of the surface of the enamel. No. 3, of corkscrew shape, is for lateral insertion between the front teeth and similar positions elsewhere.

The instrument No. 2 is employed by being inserted between the teeth at the gum, the point directed toward the coronal aspect, and is then passed along the surface of each tooth accompanied by a slight rotation of the shaft between the fingers, when, if any disintegration has commenced at the point where caries usually begins between the back teeth, it will be readily detected. The same point is equally useful to explore along the cervical portion of proximate surfaces and for examining the edges of fillings beneath the gum to discover whether caries has recurred below them. It is also well adapted to detect any surplus of gold along the cervical margins of fillings. If this point is held lightly and brought into contact with every part of these surfaces of the teeth, any defect should be revealed.

The silk employed is to be passed between the teeth to detect roughness of the enamel at parts so near of contact as to prevent the entrance of a fine probe. This means of detecting caries is not, however, to be certainly relied upon, as the silk may pass a carious point without being frayed; but it often affords positive indications of softening. It should be untwisted and but slightly waxed, as, if much coated, the peculiar feeling imparted to the finger when it encounters a rough place may be blunted.

Wedges are used in all cases of doubt concerning any part where decay may be suspected. These may be used in any suitable manner, as described in its proper place, usually, for this purpose, but a slight space being needed.

The examination of the teeth should be commenced at the median line, and the appliances for the purpose should be applied *seriatim* to each tooth in so thorough a manner that a complete knowledge of each one is had before passing to the next one. If it be found that the front teeth are carious on the proximate surfaces, the indications are that all the teeth are in danger, even when no apparent defects exist, and all such spaces should be opened by pressure to determine the state of the proximate surfaces if not otherwise ascertainable. If on one side of the mouth a given proximate surface of any tooth is carious or has been filled, the condition of the corresponding surfaces should be carefully determined by making separations.

As stated above, the necessity for thoroughness cannot be overrated. A general and widespread error is that of neglect of rigid inspection of proximate surfaces.

When the state of the oral fluids is unfavorable to caries, the feeling of the sound parts of the teeth conveyed by the explorers is one of smoothness, as though the surface were vitreous or oiled, whereas, when the oral fluids favor the development of caries, the instrument comes into an apparent real contact with the structure. The difference of feeling is like the comparative touch to glass and chalk or plaster. If the former sensation is manifested, less care may be required in opening

doubtful places than when the latter sensation is felt. Thus, often, some judgment can be formed by the first contact of the explorers, and probabilities of the conditions and tendencies of the teeth conjectured.

Positions, Rests, and Guards.

The position of the hands in operating and the rests and guards which give limitation and security to the movements of the instruments are matters of considerable importance. It is impossible to operate on the teeth with any degree of accuracy or safety without some method of guarding the hand to prevent accidental escapements. It is the absence of established means to accomplish the purpose of defining and guarding the movements of the instruments which is the chief cause of the distressing awkwardness of novices, as it is the facile use of these means which constitutes the graceful application of force by the expert operator.

The selection of easy rests and secure guards also constitutes one of the essential differences between heavy-handed and light-handed operators. It is these that make feasible the velvet-like touch and allow this by quick gradation to assume the expression of force.

There is no part of this subject which is not capable of considerable elaboration, and which is not worthy of thought by each individual operator, as it lies at the root of the efficiency of every effort connected with operations upon the teeth, and by proper extension it may without impropriety include all the demeanor of the operator which has any relation to his personal connection with the case which may be under treatment.

The foundation of all the positions assumed by the hand depends largely upon the attitude of the body. This should be sustained from foot to shoulders in a nearly erect position, the weight resting principally upon the balls of the feet rather than upon the heels, that the movements so constantly required may easily be made. The shoulders should be well back, that the arms may not be cramped and that the respiration—which for obvious reasons should always be made through the nostrils—may go on quietly and deeply. The personal relation of the dentist to his patients is usually closer than is agreeable to the sensibilities of cultivated and refined people, and, while tolerated on both sides because of the necessities of the occasion, the approach should be made with a delicate regard to the natural feeling of repugnance to the contact of another person. For this reason the personal contact should be at as few points as may give security, and the left hand should be shielded by a napkin whenever convenient.

All movements of the hand calling for precision, delicacy of touch, and the application of force require some point of rest as a basis of the action, and usually, in addition, a guard to guide and limit the action. These have to be as multifarious as the various portions which have to be operated upon. The following are given as samples of those most commonly assumed during the preparation of cavities:

Position of the Hands in Operating on the Front Teeth from the

Inside.—The index-finger of the left hand is engaged in maintaining the elevation of the upper lip; the thumb rests upon the ends of the teeth in supporting the napkin and as a guard to the instrument in use; the fourth finger of the same hand is engaged upon the forehead, acting in conjunction with the thumb in supporting the head of the patient. The instrument is held as the pen in writing; the third finger engages the outer surface of the chin; the fourth finger at the same time rests loosely beneath the chin, ready at any instant to act as a guard to protect from accidental escapement of the instrument. As intimated above, the thumb is an important guide and guard. It supplies force in lateral cutting, directs the movement of the instrument, and checks misguided efforts.

For operating from the outside the position of the left hand remains the same as described, except that the thumb is thrown more across the inside of the arch and bears upon all of the front teeth; it is then used as both a rest and a guard, as the third finger of the right hand is supported upon it. An additional guard is the engagement of the right third finger upon the outer surface of the chin.

Position of Hands for Right Upper Bicuspids and Molars.—Of the left hand, the index-finger is engaged in the retraction of the commissure of the lips; in this connection it should be observed that the point of the finger be well bent, that the commissure is drawn and not pushed into position. The pressure of this finger should at first be light, and increased as the muscles relax, as, if made severe at first, the contraction is liable to be resisting and long continued. The second finger is engaged in elevating the lip, and rests upon the outer surface of the incisor teeth; the fourth finger rests upon the forehead; the thumb is free, but lightly engages, during the cutting, the inside of the second and third fingers of the right hand. The guards are this contact and pressure of the right fourth finger beneath the jaw.

Position of Hands for the Left Upper Back Teeth.—The base of the tooth is grasped between the thumb and the index-finger; the latter at the same time is extended backward, and holds outward and backward the commissure. The fourth finger rests upon the forehead, the other two being free. The grasp of the tooth and the position of the index-finger maintain the correct position of the face. The guards of the right hand are made by the application of the fourth finger beneath the lower jaw, in the locality of the submaxillary gland. This guard gives complete security to the instrument, since the least erratic movement may by it be at once arrested. The third finger also aids by its rest upon the outside of the lower jaw. During the process of operating the thumb of the left hand frequently somewhat leaves its position, and assists the instrument by applying force to it during the lateral movements.

Position for Right Inferior Bicuspids and Molars.—The position of the operator is to the right rear of the patient. The tooth is grasped between the thumb and the index-finger. The thumb acts as a guard on the inner side and keeps the tongue out of the way; the finger is pressed downward and maintains the position of the lip. The tips of the second and third fingers of the right hand rest during the cutting

process upon the left index-finger. This support of the right hand is more secure and more comfortable to the patient than resting it upon the jaw or the cheek. The position of this guard answers equally well when the dental engine is used.

Another position, more particularly adapted for the mesial surfaces of the right inferior back teeth, is the commissure extended by the index-finger, the thumb being placed beneath the jaw to counteract the force of this finger and to sustain the position of the head, the fourth finger at the same time being upon the temple. The instrumental hand rests by its third finger upon the ends of the lower incisors.

Positions for the Left Lower Back Teeth: Mesial and Coronal Cavities.—Position of body, on right side of the patient. The index-finger is engaged in withdrawing the commissure of the lips, at the same time sustaining the napkin; the second finger is engaged in depressing the lower lip; the third and fourth fingers are applied beneath the lower jaw, to counteract the force of the first and second fingers and to assist in supporting the head; the thumb is free. For the right hand, the third finger is engaged upon the lower teeth and against the end of the second finger of the left hand; these engagements form the support and guard of the right hand. There is some insecurity when the teeth become wet, which may be obviated by extending the napkin over the face of the incisors.

For the distal surfaces of this quarter the position should be at the left and rear of the patient, the left hand as above, except that the thumb is engaged upon the ramus. The support of the right hand is then by the third finger upon the ends of the lower incisors.

These positions are subject to many modifications by the peculiarities of the cases, of the patient, and by the form and size of the operator's hand.

As the relations of the hands are the foundation of the efficient use of all the instruments, this description is made for the use of beginners, to

Fig. 44.

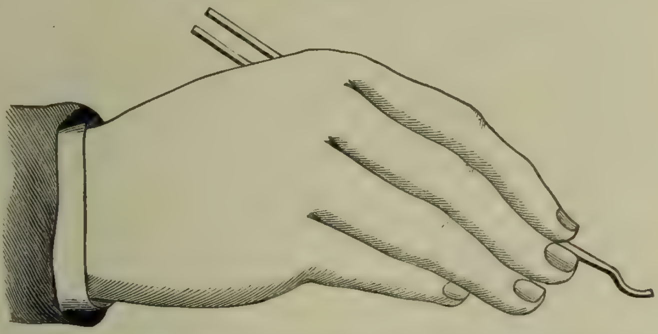
whom it may be stated as a cardinal principle that in nearly all instrumentation delicacy of touch and precise application of force require both a correct rest and a secure guard.

The position of the hand represented by Fig. 44 is one of very frequent

occurrence both in cutting and in packing gold. The thumb rests either upon adjoining teeth or upon the thumb of the other hand, as the case may be.

The position of the hand shown in Fig. 45 is also a very frequent

FIG. 45.



one in many procedures, during which the fourth finger is made to rest upon whatever contiguous firm support may be found.

TEMPORARY SEPARATIONS.

A necessary preliminary step to the treatment of caries of the proximate surfaces of the teeth is the securement of space. This is required not only to make the cavity accessible, but to prevent any unnecessary removal of structure from the margins of the tooth. In former times these spaces were made by immediately cutting sufficiently from the proximate faces of the teeth to give abundant access. This method has deservedly fallen into disuse, on account of the abuses growing out of the practice, and has been followed by procedures for the purpose which produce much better results. It is believed that Dr. E. Parmley originated the plan for making forcible separations.

Separations, as previously stated, are also required for careful examination of doubtful surfaces.

The means of producing the temporary spaces are varied according to the amount of room needed, the time in which it must be effected, the degree of firmness of the teeth, and sometimes by the idiosyncrasies of the patient. The means are immediate wedging, the swelling of cotton or tape between the teeth, and the resilience of strips of india-rubber.

Separation by Pressure.—To obtain suitable access to cavities on the proximate surfaces of the teeth, it is usually necessary freely to separate them. In former times this was done with the file and with enamel-cutters. By this means too often so much substance of the teeth was removed as to injure their appearance and impair their usefulness. While there are circumstances which will occasionally justify this, a preferable method is to make the required separation by pressure, afterward removing those thinner parts of the margins which may be too weak to be permitted to remain. This method, combined with

opening a line of approach to the cavity at a hidden part, enables more room to be secured, allows a more natural appearance of the teeth to be maintained, and ensures greater comfort to the patient when the spaces have closed than when the older plans were followed.

It is objected by some operators that separations by pressure and the subsequent closure of the teeth restore the conditions under which the carious action took place, and that, consequently, an early recurrence is nearly inevitable. This result is not the consequence, however, of the return of the teeth to their old positions, but is now considered to be generally produced by faulty shaping of the margins of the cavity and the improper form of the filling, which permitted the tooth-structures instead of the rounded surfaces of the fillings to come into flat contact.

The separation of the teeth by pressure should always be conducted with care; and if the necessary precautions are taken, there are no teeth which may not be so acted upon. Even the firmly-set teeth of matured life are susceptible of being sufficiently separated if it is slowly done.

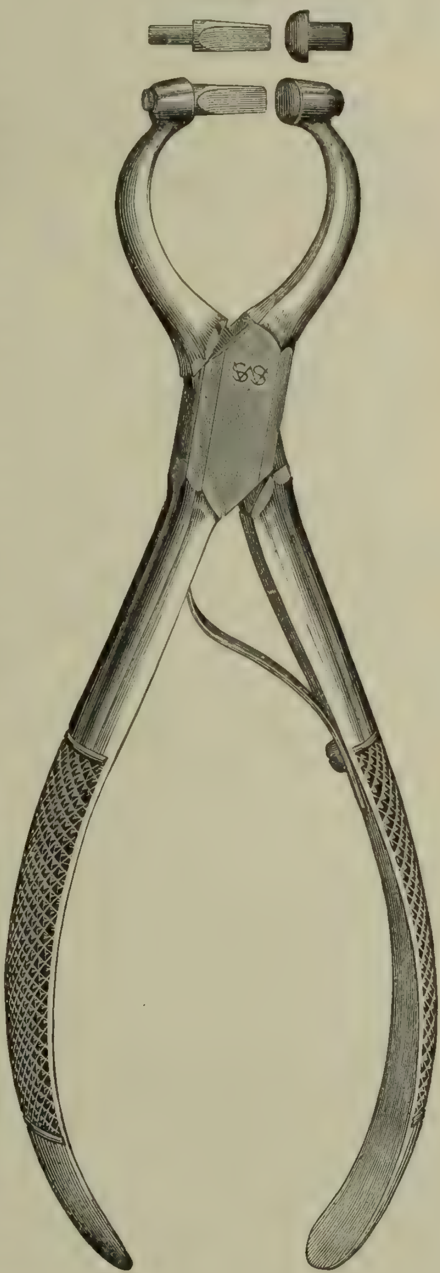
When the teeth are mobile, as in the mouths of children and of persons of lymphatic temperament, their movement is more easily and more quickly effected than where the bony tissues are dense and these organs generally in very close contact. In the former case the arch easily expands and permits the teeth to move apart, while in the latter the resistance is often so great as to require considerable time to effect the necessary separation. The force should be gentle and continuous until the required space be secured, it being very deleterious to permit repeated attempts to open the same pair of teeth. When the separation is effected, it should be maintained until all soreness has passed away; but this period of resting should not be long continued, since, if it be much prolonged, the teeth in some cases do not become so firm again as they previously were. For children this precaution is less necessary than in adult mouths, since reparative efforts are more active in the former than in the latter. In some instances, where such long-continued disturbances are made as to induce absorption of alveolar tissue, a disposition is produced to continue the absorptive action.

The amount of space required varies so much that no definite rule can be laid down for it. In general, however, for the front teeth little is needed, as the space can be increased as much as may be required by further application of wedges or of separators; but for the bicuspids and molars much more is generally required, for the reason that greater latitude is needed for the movement of instruments and to permit the proper building out of the fillings.

Immediate Wedging.—This is most applicable to the front teeth when but a small amount of space is required for the examination of doubtful surfaces and for the treatment of small cavities. The following method was first intelligently described by Dr. C. Palmer: A thin guard is first placed at the gum, to protect it from irritation, when two wedges of hard, close-grained wood are inserted, one at the neck by the gum and the other near the points of the teeth. The one at the point is driven by light, sharp taps of a mallet, when

whatever space is thereby made is taken up by driving in the same manner the wedge at the gum. This is repeated over and over again until all that can be secured in this manner is gained. The square wedge at the neck of the teeth is permitted to remain during the operation, to retain the space. By its absorption of water it will still further increase the separation during the progress of the preparation of the cavity. The best wood to be used for these wedges is boxwood. It must be confessed that this mode of separating appears to be harsh, but it has many advocates, who maintain that the irritation is less than where the same result is produced by other quick means. As soon as the teeth are released they almost immediately return to their normal place, and there is no subsequent disturbance. Connected with this method is often an apparent reduction of sensibility of the dentine, which is by some attributed to slight impingement upon the cord at the foramen, and by others to stretching of the nerve at this point.

Fig. 46.



Chase's wedge-forceps are claimed to separate the teeth with less irritation than wedging by hammering. As shown in the accompanying cut (Fig. 46), one limb of the forceps is furnished with a pad of rubber, which is placed on the lingual side of the teeth, to prevent the inward pressure injuring the tooth while the wedge with which the other limb is armed is being forced between the teeth. This space is secured by a wedge at the gum. It is claimed also that bicuspids and molars can be as easily separated in this manner as front teeth.

Dr. Jarvis's separators (Fig. 47) were invented for similar purposes, but unless some previous loosening of the teeth by other means is first effected they are not to be depended upon.

Dr. Perry has after long-continued experimentation and improvements

Fig. 47.

produced a series of separators differently formed, but acting on the same principle as Dr. Jarvis's. These inventions are shown in Figs. 12, 13, and 14 of the previous section.

All of these methods of immediate separation are more efficient if a slight space be previously produced by some painless method. They are then more prompt and less disagreeable to the patient.

For the slower methods of separating by pressure there are several materials to be selected from—viz. India-rubber, tape, cotton, sea-tangle.

India-rubber, when it is tolerated, is the most satisfactory means of producing slow separations. It acts promptly and certainly, on account of its active resilience. This in some mouths produces considerable pain, while in others scarcely any disturbance is observed. Some patients, even when the pain is slight, manifest the greatest repugnance to this means, it exciting in them excessive nervous irritation out of all proportion to the soreness. For these reasons it is necessary at the first application of this material to be careful to gradually commence its use.

The rubber, which acts by its resilience, is drawn between the teeth, and in the course of two days usually moves the teeth nearly its thickness. On account of the excessive elasticity of India-rubber, it is liable to great abuse, since, if the piece inserted be too thick, the amount of soreness may be made excessively great. In consequence of this, injury has been inflicted in some instances; and much pain is often unnecessarily caused by allowing the strip of rubber to become forced down upon the gum, where it embeds itself and ceases to be of any service in separating the teeth. This occurs only in the back teeth, and can generally be prevented by first drawing the strand between the teeth in such a manner as to permit a portion to extend beyond the coronal surface; or the piece may be placed between

the teeth, and the lingual end then drawn back through the division until it reaches the outer cusps, when it is cut off with sufficiency of free end to prevent its escape against the gum. If a large space is required, the effort should be divided into two stages. The space obtained is then secured by packing gutta-percha into the interstice, which retains the opening.

In some cases, where there is difficulty in retaining gutta-percha, oxychloride of zinc or phosphate of zinc may be advantageously used. The first preparation may be made of service also in correcting at the same time the sensibility of the dentine if before its introduction the softer caries be removed; for which, see the section on Treatment of Sensibility.

The least discomfort to the patient will be found in the use of tape and cotton. These means are slower and much more troublesome, as they have to be successively applied by increasing thicknesses until the necessary movement has taken place. The patient, however, may in some cases be instructed to insert the tapes, in anticipation of the operation. On account of the difficulty of introducing tape between teeth in close contact, it is frequently necessary first to insert a piece of rubber dam, after which the tape is easily introduced.

Cotton is applicable only when there is a cavity of notable but not great size, it being applied by being packed with considerable firmness into the carious cavity, and by its swelling therein the teeth are forced apart.

Sea-tangle tent—a substance prepared for surgical purposes out of the stem of one of the seaweeds—has a use where it is difficult, on account of the existence of large cavities, to use rubber or tape. A piece cut from the cylinder is inserted in the cavity, when it tends to expand to great size and expends its force upon the teeth in much the same manner as cotton does in the smaller cavities. As this material expands principally in its lateral directions, it is necessary to cut longitudinal strips from the cylinder. The only cautions required are to avoid applying it where the pulp of the tooth may be exposed, and not to cut away the coronal plate of enamel.

Very necessary adjuncts to the process of separating the teeth are the wedge-forceps, shown at Fig. 10, and the wedge-cutting forceps, shown at Fig. 11.

Treatment of Superficial Caries.

When caries has commenced to attack the proximate surfaces of the teeth, the natural inquiry arises whether it may not be successfully treated by mechanical removal and the subsequent polishing of the cut or filed surface. This method of treatment was practised considerably in the earlier history of dentistry—at times with success, but more frequently with failure to arrest the destructive action. There was always considerable disfiguration when this treatment was applied to the anterior teeth, and much impairment of use when applied to the posterior ones. The plan of separation at that time was to cut nearly through to the gum and permit to remain there a portion of intervening enamel, to prevent the

cut surfaces from coming into contact. The opening, at the same time, was usually made larger at the palatal aspect. It is at once obvious that this plan is inapplicable to any teeth but those of square form having parallel sides. This plan was practised even when the carious action had somewhat extended into the dentine, and was excusable only on the ground that the practitioner at that time had not the skill successfully to perform small stoppings upon the proximate surfaces of the teeth. On account of the failures, the unsightliness, the advancing skill, and the general improvement of dental surgery, the method as a system of treatment was abandoned.

There are, however, occasional instances where the necessity exists for electing this plan of treatment of isolated cases in preference either to at once cutting into the enamel and forming a shallow cavity or to waiting for the further progress of the caries. Where this is done it becomes necessary to remove the softened part, at the same time cutting away so much of the adjacent solid structure as will enable a plane surface to be produced. The cutting is done by chisels or enamel-cutters of various simple forms, which are supplied for the purpose under the appellation of "hard bits." They should be comparatively thin, square-edged, of the finest steel, and tempered very hard. The form of the edge allows them to be used to plane rather than to chip the surface. These instruments have the advantage of permitting the cutting to be confined to the parts it is desired should be cut, which is not the case when files are used. For cutting the inner portion of the space small and thin corundum disks and corundum points are useful. These disks are useful for making partial separations of the inferior bicuspids. After using these disks the cutting may be completed with the enamel-chisel.

After as much cutting as may be necessary is done the surface should be freely polished, at first with corundum-flour, then pumice, and lastly oxide of tin. These powders are employed upon pieces of tape or of wood; the admixture of glycerin with them adds greatly to their efficiency. Where superficial spots of softened enamel are found upon the outer surface of the molars, or on any part exposed to full friction, there may be permitted, without danger, some exposure of dentine and slight concavity of the treated surface. In treating the front teeth in this manner the plan of cutting should be different from the older methods, and may be made more successful in its results. It may be set down as an axiom that the operation should not be performed for children if the dentine has been touched, nor for adults under the same conditions unless the dentine be dense; within these limitations the treatment is legitimate. The teeth should first be separated by pressure, for which immediate wedging is usually to be preferred. The method of temporarily separating the teeth will be found described in its proper place.

The plan of the cutting should be to direct the plane of the cut in such a manner that, while the teeth should touch at a small point near the cutting edge, they will be permanently apart near the gum. At the same time, the inner portion of the space should be made larger than the outer portion. The form of the surface should appear slightly rounded. If this be the given form, the effort of the patient, combined

with the force of mastication, will keep the parts clean and polished. The points in contact will be kept polished by the friction as the teeth move against each other.

There is one consideration which should never be overlooked in treating the teeth of children in this manner, and that is the frequent tendency of the front teeth to overlap. If there be the slightest deviation toward rotation of any of them, any interference of the kind described will inevitably tend to enhance the action. It is obvious from this statement that this operation is fatally reprehensible in the case of irregular teeth, for which it has not unfrequently been recommended. The results usually are far more repugnant to the eye than is the irregularity of the natural forms of the teeth. This treatment will be frequently applicable in practice as a consequence of the pernicious influence of a contiguous cavity, when the two cases will have to be often treated with careful judgment; but generally the plan herein laid down will be applicable to superficial caries when the form of the deeper-seated one has been restored.

Operations of this kind upon the bicuspids and molars, except in the space between the inferior bicuspids, is usually questionable, if not inadmissible, for several reasons. To be efficient considerable cutting is requisite, which greatly disfigures the teeth. The form of the artificial space, being wedge-shaped, ostensibly to prevent flat closure, permits the food to be forced against the gum, to the discomfort and ultimate injury of the patient. If the operation is performed for the young, the teeth will change their positions and come into flat contact, with a subsequent renewal of caries and the production of consequences far more serious than if the decay had been permitted to increase to such a degree as to require filling. Whenever this operation is performed, considerable caution should be enjoined on the patient to maintain cleanliness of the cut surfaces. Some years since Dr. Arthur proposed, and in his practice carried out, a system of separating teeth for prophylactic purposes which he defended in a treatise.[1]

Some review of this subject is appropriate here. Dr. Arthur set out with the proposition that at the present time a large proportion of persons are certain to suffer the occurrence of proximate caries of their teeth, and that it is within the skill and knowledge of intelligent dentists to determine in advance these cases. This was coupled with the observation that when teeth are naturally well apart they have immunity from decay, that when they present but slight points of contact they have comparatively little caries, and that when they have been separated by filing by the older dentists they have often been preserved from further destruction. Accidental injuries of the teeth which expose the dentine, and the practice of aboriginal races of filing the teeth for ornamental purposes without harm to the dentine, supported the proposition that the dentine might be broached without inflicting injury to the teeth. As the teeth nearly in contact were attacked and the teeth not in contact had immunity, the fundamental reasoning was that if spaces were made the friction of mastication and the care of the patient would prevent the occurrence of caries. In addition to this, it was

[1] See *Treatment and Prevention of Decay of the Teeth*, by Robert Arthur (1879).

observed that the point at which caries most frequently occurs on the proximate surfaces is not where they are farthest apart, but where they are about to come into contact. By maintaining a separation it was believed this weak point would be eliminated; it was therefore proposed by Dr. Arthur to separate all the teeth where the indications appeared to demand it, and to maintain the separations by repeated cutting if it became necessary. This was done for the front teeth by the means described above for the removal of superficial decay. The back teeth were separated by means of thin corundum disks, some of them being of considerable diameter.

This principle of practice did not receive general sanction, and has grown into disfavor because of the consequences following the injudicious application of the method in very many instances.

For the front teeth there are circumstances where it might be justifiable to separate and polish somewhat in advance of the actual commencement of softening, but this is scarcely the place to lay down indications which might be misunderstood, since so serious a step should be taken only by one of excellent judgment and long experience. It will suffice here to state that the general indications for interfering are that the teeth should be of soft texture, of dull appearance, and that the commencement of softening be observed between the central incisors. These conditions are indications of the existence of active predisposing and exciting causes of caries, and demand the greatest energy and the employment of the most urgent means to remedy the results of these general disturbances and to counteract their influences.

After the operative procedure the cases require frequent inspection and the most thorough care by the patient in the use of the pick and by polishing with tapes and chalk.

The application of the practice to the posterior teeth, on the other hand, is fraught with the most serious consequences in cases where the indications exist for fearing the occurrence of general proximate decay. When the greatest necessity exists, this means will prove the more disastrous, and only when the tendency to decay is comparatively slight is it likely that prophylactic cutting will here prove of any avail. Whatever form of separation may be used, the teeth either close up again or the point of predisposition is changed. If the teeth remain apart, the food impinges upon and produces irritation of the gum, which soon induces carious action at the proximate surface, near the gum. If the cutting is not made entirely through, the near point is simply at length shifted nearer the cervix, and the conditions remain unaltered.

With the light now had upon the causes of dental caries, the proposition to separate the posterior teeth cannot safely be entertained as a means to prevent their decay.

Treatment of Sensibility of Dentine.

The general principles underlying the subject of sensibility have already been considered in Vol. I., to which the reader is referred. It only remains to consider this subject in its immediate surgical

aspects, with strict regard to the practical treatment of this condition in connection with the preparation of carious cavities.

When a healthy tooth is fractured, or when, from any cause, the dentine, without shock to its vital connections, is mechanically exposed, if an examination be made of the surface of the denuded dentine, it will be observed to be nearly devoid of sensibility; but after the course of twenty-four hours or more this same surface, if nothing be done to counteract the influence of external agencies, becomes extremely susceptible to the impact of foreign substances, to the chemical influences of such simple excitants as sugar or the salts, and is also impressed by the application of cold, and in some instances of heat; even the passage of the tongue may excite irritation. When the exposure of the dentine has been effected by carious action, the result is liable to be the same as when the denudation is accidental; and the sensibility manifested is governed by a variety of considerations, such as the degree of rapidity of the progress of the carious action, the relative density of the structures and by certain physical peculiarities connected with constitutional conditions unfavorable to curative and reparative effort, probably associated with an excessive tendency to the development of bacterial forms of life.

a. The degree of rapidity of the progress of caries has the largest qualifying influence over dentinal sensibility, as it is an expression of the activity of the exciting causes of caries. When the caries proceeds with great rapidity, the organic elements of the tooth are denuded to a proportionate degree, and, as these elements in their exalted condition are the means of extending the irritation to the pulp, of which they must be considered prolongations, it at once becomes evident how important a fact the rapid progress of caries is and how much it must increase all the morbid concomitants of dental decay. On the other hand, when the carious action is of slow progress, the amount of organic tissue exposed to irritation is of a minimum amount, for the reason that the familiar morphological changes of eburnation of dentine have gone on coincident with the slower carious action. The slight irritation of slow caries is to a certain extent an encouraging influence to secondary tubular deposits of calcific matter, which, if the caries had been more rapid, would have excited so great an irritation as to have limited or altogether to have prevented the consolidation.

b. The relative density of structure also qualifies the condition under consideration, for the reason that when the tissues are soft, even when slowly acted upon, the decomposition exposes a larger amount of organic fibre, and therefore adds to the local pain as well as tends to the enhancement of hyperæsthetic conditions of the pulp, which in turn exalt the local susceptibility. The increase in the amount of organic matter present at the living zone surrounding the carious action has a still more important influence than is found in its mere exposure, since the amount and size of the tubular contents occasion them to be subject to a greater degree of bacterial irritation than would be the case if the dentine were dense; and thus the surface of the tissue is liable to disturbances in addition to that caused by the decalcifying process.

c. The influence of cachectic conditions, such as the scrofulous and

syphilitic, in qualifying carious action and modifying the resultant sensibility is immediately connected with the preceding consideration. These are usually attended with want of density of dental tissue, and are accompanied, in addition thereto, by such a lack of recuperative energy and reparative force as to make the prognosis of all diseased conditions of an unfavorable character. These states render the treatment of dental caries at all times difficult and uncertain, and raise the question whether, when these conditions are present, permanent results from dental restoratives can be realized. It is futile to attempt severe operations with the metals when we have, as is so often the case, the combination of low vital force with softness of structure and active exciting causes of carious action.

It may now be considered clearly established that dentinal sensibility is attributable to the state of the tubular contents, and that it is excited into extreme manifestation by some physical irritation of these not yet clearly determined fibrillæ.

The combinations of conditions above related produce those extreme manifestations of sensibility the dentist is frequently required to treat, the practical consideration of which must now be entered upon.

As to the general characteristics of dentinal sensibility, the one of first importance is that its extreme manifestation, when decay is proceeding, is to be found directly beneath the carious tissue, and is greatest immediately where the dentine is in a state of partial disorganization. Further, the portion of the tooth where this manifestation is greatest is near the line of junction of the enamel and dentine, and also on the direct radiant line from the cornua of the pulp to the periphery of the dentine. The deeper parts of the dentine—at least, in well-developed teeth—have, in consequence of structural changes of the tubular contents, become incapable of conveying acute sensations to the pulp proper, and even in the case of soft dentine, wherein these tissue-changes are less frequently observed, the sensibility is not so great at the bottom of the cavity, near the pulp, as it is at the periphery.

This condition, when extreme, offers one of the most serious impediments encountered in the removal of caries, and often during the preparation of cavities for persons of much susceptibility to pain becomes so severe as to be unendurable. The general dread of this peculiar pain deters many from having needed operations performed upon their teeth. The apprehension of pain also increases the susceptibility to impressions of this character by weakening courage and exciting the imagination to anticipate at each successive touch of the instrument a greater pain at the next.

The first requisite is an assuring manner, an earnest but quiet sympathy for the patient, combined with a light but firm touch and an assurance that whatever can be shall be done to mitigate the pain of the operation. In this connection it is an important and laudable object to remove the dread of patients and secure their confidence. This is generally best accomplished by selecting the simpler cases for the first operations.

In the performance of the simpler cases of ordinary sensibility, the pain in many instances arouses the moral courage of the patient and

facilitates the advancement of the work. The opposite course—of lack of sympathy, of stolid indifference, of needlessly rough cutting—alarms at each cut the suffering nerves, and at length lashes the apprehension and inflames the nervous exaltation of the patient to such a degree that progress is checked and future operations are approached with dread.

While, in many cases, the infliction of some pain is an inseparable accompaniment of dental operations, it is inexcusable for any one to cause severe suffering. It is not humane to do so, nor is it in the direction of the certain preservation of the greatest number of teeth from destruction.

In many instances of ordinary sensibility little more is required for persons of health and endurance than the employment of very sharp thin instruments, which should be wielded with a light hand and by rapid movements. After a short period of cutting the healthy bone is reached, when usually there is much diminished sensibility.

The movements of the instruments should generally be in a direction away from the pulp. Besides the risk of cutting in directions toward the pulp by what may be called push-cutting, the pain is manifestly greater than that caused by the passage of the instruments in the opposite direction.

When the dentinal sensibility is so great as to necessitate treatment, there are several courses to be pursued to diminish or to remove it, and the selection of one or the other has to be determined by the existing conditions, combined with some previous knowledge of the peculiarities of the individual. A remedy which may in one case give certain relief may in another be of little service.

The most important of these remedies are warmed air, carbolic acid, either alone or combined with acetate of morphia or tannic acid, tannic acid in combination with glycerin and veratrin, chloride of zinc, and, in special cases, nitrate of silver; also anæsthesia by the administration of sulphuric ether, and most rarely arsenious acid and arsenide of cobalt.

The first of these, warmed air, is most serviceable in the incisors and bicuspids, and frequently proves of great value. The therapeusis is effected by the removal of one of the elements of the exposed surface of dentine, the water. If it were possible to effect complete desiccation of the surface, the deprivation of sensibility would necessarily be complete, but usually this can be only imperfectly accomplished. Even then the benefit is often very great. In many instances the remedy is simple and easily applied, and, while the pain of the application is sometimes quite considerable, it soon passes away, and after a few moments the case is reduced to a state of slight and simple sensitiveness.

The application of heated air is facilitated by excluding the entrance of moisture by the most efficient means and then injecting air from one of the variously-formed air-syringes. Those which have a copper cell containing a series of alternately perforated diaphragms to be heated over a Bunsen burner are the most suitable. The blast should be used, gently at first, at intervals of a couple of seconds; as the pain diminishes by the extraction of the water, the force should be increased and the inter-

missions become shorter and less frequent, until the pain ceases, when, in most cases, the operation can be proceeded with. The credit of making the discovery of the relief of sensibility induced by the desiccation of the surface of the cavity by means of injected air is due to Dr. Brockway.[1]

Carbolic Acid.—It will also be found that after partial desiccation of the surface has been accomplished the employment of carbolic acid to it will be of efficient aid. This agent, from its slight solubility in water, is not of much service as a means of immediately obtunding dentinal pain, but after the partial drying of the dentine it enters more deeply and produces a greater impression. To secure a satisfactory result by the employment of carbolic acid under ordinary circumstances without desiccation, it is necessary to dress the dried surfaces of the cavity with it, either simply or in combination with acetate of morphia—or, better, tannic acid—and to then seal it up for a few days by some of the easily-removed impermeable plastics. It is usually quite futile to attempt immediate operation after having in vain applied heated air and then made resort to the means now indicated.

Recently a comprehensive and efficient arrangement for compressing and for applying air was devised by Dr. Register. The compressed air is conveyed in India-rubber tubes from the fixed pipes of the reservoir. It may then be used by means of an atomizer for forcing medicaments into cul-de-sacs, into canal-fangs, through the course of alveolar fistulas, or may be directly employed for drying various surfaces and also for obtunding sensibility of dentine. When desired for this purpose, the bulb of the air-syringe is heated over a Bunsen burner, when a constant stream of air of any desired temperature may be delivered into the cavity.

Veratria.—Dr. Bogue strongly recommends the use of veratria in combination with carbolic acid. The formula is

Veratria,	gr. vj.
Pure carbolic acid,	gr. vj.
Absolute alcohol,	m. vj.
Glycerin.	gtt. v.

The method pursued by him is to protect the tooth by rubber dam, apply the medicament, and proceed with some other case. On returning to the first one it is cleansed with alcohol, and after air-drying the cavity the excavation is proceeded with.

Chloride of Zinc is a sovereign remedy for the relief of the conditions now being treated, and when properly applied is followed by the most remarkable and satisfactory results. It is applicable in all cases where the cavities are not so deep as to endanger the action of the chemical upon the dentinal pulp. On this account only it has to be employed with caution. Chloride of zinc appears to act by two distinct physical effects—one, the coagulation of the albuminous contents of the tubules; the other, the abstraction of water, on account of its extreme affinity for that element. It is easily recognized that any agent which has the capacity to deprive the surface of any tissue of one or more of its elements must so far lower its capacity for irri-

[1] *Dental Cosmos*, vol. xiv. p. 19.

tation. It has also, fortunately, in its favor the important quality, consequent upon its coagulative power over albuminous substances, that its action is limited by the immediate expression of this power to the surface of the dentine exposed to its action. So soon as this has extended nearly through the zone of exalted tissue, which is of limited depth, the stoppage of the pain indicates the time for the removal of the drug, which is effected by washing it away and giving access to the fluids of the mouth. If it were used in excess and its action extended by time, there would always be danger of deep-seated injury, as its energy would not terminate until the affinities of the whole amount had become satisfied, which in cavities at all deep would eventuate in disorders of the pulp.

There exists a very wide distinction between chloride of zinc and arsenious acid. Both substances have a similar power in reference to their affinities for albumen; both combine with this element of the dentine and deprive the bone of sensibility. The first, with the qualifications above stated, is absolutely a safe agent; the latter, except under circumstances and conditions to be hereafter described, is always dangerous and its use of doubtful propriety. The first, as far as it acts, appears to set up its own barrier and to have a clear and well-defined demarkation between the devitalized and living tissue. The affinity it has for water as soon as this is admitted deprives the devitalized part of the tissue of any remaining portion of the excess. Arsenic, on the other hand, while its action gives no pain when employed for this purpose, has no clear line of demarkation. Its affinities for albumen are not so striking and do not appear to occur until after it has paralyzed the vital powers of the tissue to which it is applied. On this account its line of demarkation is not nearly so well defined, and its action is obviously liable to extend to a dangerous degree.

This comparison is made here to enforce the marked differences in action of these two remedies, and will be of service when the use of arsenic is described.

To secure the proper action of chloride of zinc, it is essential perfectly to protect the cavity from the ingress of water, whether by the inflowing of saliva or by the insensible entrance of any fluids by capillary approach. It is also important to exclude the vapors of the mouth. To make sure of the exclusion of all moisture, it is necessary to envelop the tooth—and frequently, also, its neighbors—with rubber dam, securing it with a thread at the gum. If the cavity be a simple one, it should have placed in it, after being dried, a pledget of cotton filled with the saturated deliquescent solution of the chemical. It is necessary that the agent should be chemically pure and liquefied, and to secure full saturation it is important to observe that the vessel always contains some of the undissolved crystals.

The remedy generally causes pain at first, and in some cases this pain is extreme. This can be modified by air-drying the cavity and applying for a moment carbolic acid, the carbolization of the cavity appearing not to interfere with the action of the chloride.

In deep cases the part of the cavity nearest the pulp should in the beginning be perfectly protected from the action of the agent, and, as

the sensibility of the dentine is considerable only at the periphery, the usual objection to the remedy is removable.

The remedy should be permitted to remain until all the pain it causes has passed away. It will be frequently observed that the pain diminishes very much after a little while, and then recurs. It is not until the secondary pain has subsided that the excavation should be performed.

There are several reasons why chloride of zinc has not had the general repute to which its properties entitle it. It has by many practitioners been regarded as a very painful and uncertain remedy. This has not agreed with the writer's experience, who has made it his chief reliance in severe cases for many years, and who regards it as the only certain and reliable escharotic for this purpose when warmed air and carbolic acid prove inefficient. The uncertain results from its use may have arisen from disregard of the means necessary to secure its efficiency, combined with an indisposition to tolerate the delay which attends its use. This delay, however, is more apparent than real, as what time is lost in futile attempts to manipulate very sensitive cavities in misdirected and inefficient efforts is more than compensated for by the freedom and rapidity with which the case may be proceeded with after the treatment is over. An excellent method to obviate the loss of time is to apply the rubber dam, make the application as above described, pass a ligature around the free portion of the rubber, at a short distance from the tooth, so tightly that water cannot enter, and then cut off the extruding portion of the rubber. Operations can then be carried on in connection with some other case in another part of the mouth until the sensibility is believed to be subdued. The cavity, after being thoroughly washed and permitted to remain open for a short time, to allow the excess of zinc chloride that has not combined to be dissolved away, may be filled temporarily if impracticable to complete the operation at that sitting. The postponement of such cases when treated in this way is frequently advantageous. Sensibility, treated in this manner when the remedy under consideration is indicated, is usually followed by the most satisfactory results.

There remain to be considered the general principles guiding the selection of this remedy. Although, when its administration is continued for no longer time than is required to subdue dentinal sensibility, it cannot penetrate deeply the tubular structure because its combination with the albumen limits the depth of its action, still it has energetic properties and is inadmissible under several conditions.

As it can do harm only by an extension of action upon the organic elements of the dentine, it will at once be observed that in all cases its danger is in proportion to the softness of the structures and the near proximity of the dental pulp. It is therefore manifest that in teeth of hard structure not near the pulp danger would be less marked than in softer teeth at the same distance from that organ. In the harder teeth, also, where usually the caries is less rapid and the consolidation over the pulp more nearly complete, the safety must be greater than where the opposite conditions exist. In all cases, however, the extreme sensibility is always found at the peripheral limits of the tubules, and,

as before pointed out, it is not at all difficult to limit the action of the zinc to that part alone; and in practical experience it is found necessary to protect the central parts of the cavity only in teeth of soft character and in the incomplete teeth of young subjects.

Another form in which chloride of zinc is applied is in a paste made by combining it with oxide of zinc, which soon becomes hardened by the union of the two elements. The result is produced by the action of the free solution, which must be in excess. This means is often efficient if some days are permitted to intervene before completing the case. The same qualification stated above is needed when the pulp is nearly exposed, and some care should be exercised in soft teeth because of the long continuance of the action.

Occasionally the agent under consideration, even after all the foregoing precautions are taken, may prove inoperative. This seems at first sight to be inexplicable, as the remedy acts by combining with the organic elements of the dentine. The probable solution is that the vital resistance of the tissue is sufficient to obviate the chemical affinity.

As an obtundant of sensibility in extremely shallow cavities, where the adjacent tissues may be protected from injury, chromic acid and nitric acid are often of service; each should be applied by means of a gold-pointed instrument.

Nitrate of silver is serviceable for the sensibility occurring after the removal of superficial caries and for that form of sensibility which occurs at the necks of the teeth, but is admissible only at the back of the mouth. It also possesses some preventive power over the occurrence of caries in such places.

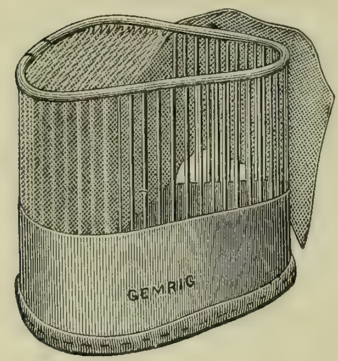
Anæsthesia produced by Sulphuric Ether.—This is indicated when the sensibility is extreme, when the previous remedies have proved inefficient, and when from the nature of the case chloride of zinc is inadmissible. The influence of the ether should not extend into the second stage of cerebral excitement, as dentinal sensibility yields to the influence of the anæsthetic at a very early period of the administration.

This is an important feature of the use of ether for this purpose, as, in case the anæsthetic influence is allowed to proceed farther, nothing can be accomplished because of the automatic resistances which frequently occur in the second stage. To advance to the third stage of anæsthesia is neither warranted nor practicable, since some volition on the part of the patient is a necessity. When the person under treatment is one of intelligence or one who reposes full confidence in the operator, if the necessary explanation is made beforehand, it is rarely required to produce unconsciousness; the moment the recurrence of the pain commences a couple of inhalations are sufficient to allow the case to be continued. The administration, made in this way, is usually entirely without subsequent depression. In this manner exquisitely sensitive surfaces can quickly be made ready without the least suffering. The time usually required to produce a sufficient degree of insensibility rarely exceeds three minutes, providing the ether be pure and there be a sufficient admixture of the atmosphere with the vapor.

The best ether procurable at present is that manufactured by Dr. Squibb.

The most suitable form of inhaler for this purpose is the one invented by Dr. Allis (Fig. 48), which consists of a frame covering a number of layers of muslin stretched near together, and yet so much separated as to permit a free passage of the atmosphere during the period of inspiration. While these parallel layers give up a large amount of the ether, there is no sense of discomfort to the patient, on account of the dilution of the vapor.

Fig. 48.



The proper manner to apply the ether is to maintain an almost constant slow dropping of it, which maintains the meshes of muslin in an even degree of saturation throughout the administration. If, on the contrary, a quantity is poured on from time to time, there are intervals when the supply is deficient and moments when the quantity of vapor is stifling. This instrument and this means of employment are of incalculable value to the dental operator.

The writer has used ether in this manner with the happiest results in the extreme sensibility of little children and of females when without its use no operation could successfully have been performed.

Temporary Fillings.—The insertion of temporary fillings is another important means of relieving sensibility, but usually it is applicable only to deep cavities of a great degree of sensitiveness and of near proximity to the pulp, which precludes complete preparation for the insertion of permanent fillings. Temporary fillings for this purpose are of two classes, metallic and non-metallic. Of the former, tin foil possesses the most advantageous properties. This metal, being soft, is easily packed into place, retains its position well, and is more easily and more perfectly brought into contact with the walls under the above-mentioned condition than any other of the metals. The various amalgams are also well adapted when the form of the cavity is favorable. The formula for this purpose should be largely of tin, like the Townsend amalgam. The relief afforded by these fillings is produced by the slight thermal irritation, which excites calcification of the tubular contents.

The last-named class comprise gutta-percha, phosphate of zinc, and the oxychloride of zinc. The first of these substances is of little value, for the reason that its non-conductivity of heat preserves the part from irritation; so that the only relief—which is usually slight—grows out of the protection from external irritation. The same results attend the use of oxychloride and zinc-phosphate, but to a somewhat less degree. The first irritation of phosphate of zinc has not much energy and is of short continuance; it is therefore adapted to the dangerously deep cavities. It also is a non-conductor of heat. This substance, however, is so deficient as a filling material that even for this

purpose such stoppings must be kept under close observation. Oxychloride of zinc, on the contrary, is irritating at the outset, and the irritation is longer continued; and both effects may be enhanced by mixing the oxide with the saturated solution of the chloride. The result of this strong formula is to excite a longer period of action to produce a similar effect to the direct action of the chloride. It must be borne in mind, however, that this means is not adapted to deep-seated cases and must be governed by the same cautions as qualify the employment of chloride of zinc.

Arsenious Acid.—On account of the certain destruction of sensibility following the employment of arsenious acid, this has been a seductive remedy for the treatment of dentinal sensibility and has inflicted incurable damage, having been much employed by careless and unscrupulous operators. It should be used only as a last resort, with the most extreme caution, and only by those who are well acquainted with the character of this substance, with its mode of action, and with the means of its employment. The conditions covering its use are that the cavity should be of the greatest sensibility, that all other means of relief have failed, and that the decay must be of such extreme shallowness as to render impossible the retention of any kind of temporary filling. The slight depths permit the subsequent excavation to be continued so far as to get beyond the influence of the arsenic; otherwise, the pulp will eventually become devitalized.

The precise mode of action of arsenious acid is not clearly known. Even when present in quantity so minute as to escape delicate tests or to defy analysis, it appears to possess the power to devitalize the dental pulp, although it may, in this degree of dilution, have no perceptible influence on the other tissues. For this reason no amount of caution in its use, where its employment is indispensable, should be omitted.

It can scarcely fail to prove useful to here make a description of the unfortunate results of the action of arsenious acid which may occur when it is applied for the relief of dentinal sensibility.

When arsenic is applied to sensitive dentine, it is invariably found to effect the devitalization of this structure in a period which rarely extends over twenty-four hours. In some cases loss of sensibility has been observed to take place in six hours. If the cavity be a deep one, it is not many days before the arsenical influence upon the body of the pulp becomes marked, which it reaches through the short course of the tubuli at the deeper parts of the carious cavity. The general result of this action is a violent congestion of the pulp which mostly is of short duration and is followed by devitalization of the tissue throughout its whole extent. This is apparently caused by the occurrence of strangulation at the apical foramen. This condition is attended by profound disorganization of the corpuscular elements of the blood and the infiltration of the dentine by the coloring-matter. The consequence of this is an invariable and marked deep discoloration of the tooth. So suddenly are these positive results developed that no attempt to avert the threatened discoloration can be made with any prospect of success.

When, on the other hand, the cavity is extremely shallow, and also highly sensitive, the tissue has no ability to resist the paralyzing power

of the arsenic, as sometimes appears to happen under chloride of zinc. The case may then be prepared with the greatest comfort. But in a variable period—sometimes after weeks or months—there appear evidences that the pulp has suffered the loss of its vitality. The death of the pulp in these cases is usually not followed by the violent symptoms and serious conditions which ensue after the employment of arsenic in deep caries. The tooth loses its natural tone of color and may not acquire a deep shade of discoloration unless the remedy has been carelessly used. In some instances, at length, disturbance of the peridontium takes place consequent on the putrefaction of the pulp-tissue. In other cases these manifestations do not occur, and the tooth may remain quiescent for a long period. Correct practice, however, requires that such teeth be opened and the pulp-cavities treated, to arrest the liability to apical derangements.

In the first class of these cases it is not difficult to trace the effects to the direct action of the poison, but in the second class this is not so apparent. The quantity of free poison may be so small, after it has combined with the albuminous elements of the contents of the canaliculi, as not to appear sufficient to excite irritation. In this connection the limits of the subject do not allow more than to call attention to the known influence of arsenic in minute quantities upon the tissues. These are the production of fatty degeneration, the disorganization of the blood-corpuscles, and its elective tendency to attack the epidermal structures.

When it is necessary to use arsenious acid, an extremely minute amount of the dry, finely-divided powder should be applied to the cavity, and be hermetically sealed. The time of its retention should be not over three or four hours, and the excavation should take place in from twelve to twenty-four hours, and never later than the latter period; and, as before stated, the cutting should be free and be continued until sensibility is reached. It is obvious that more liberal cutting should be made at the surface opposite the pulp than near the margins.

Another form of arsenic—an arsenical ore of cobalt known also as zaffre and bluestone—possessing the same power over dentinal sensibility as arsenious acid, is a less dangerous agent, because it is feebly soluble in the fluids of the teeth. It should be applied in the form of powder, be placed in the cavity with the same care and precautions stated in the previous paragraphs, and be allowed to remain eighteen to twenty-four hours. All traces of the medicine should be removed at the end of that time, when in many instances it will be found that the sensibility is increased, but at the further period of twenty-four hours, or less, all traces of sensitiveness are gone. It is then necessary freely to cut away the dentine exposed to its action until sensibility is developed, when, if the cavity is shallow, no danger need be apprehended.

This subject would not be complete without some consideration of these two dangerous remedies, and it is required here to emphasize the caution that no excuse exists for the use of either except on account of the most urgent necessity, and that they should not be employed unless the patient is well aware of the consequences of neglecting the appointments made for the removal of the medicaments and for the subsequent excavation.

The Preparation of Cavities.

The preparation of carious cavities for the reception of gold or tin may be divided into three general procedures: the opening of the orifice, which includes the definition of healthy margins; the excavation of the carious portion; and the formation of the cavity to adapt it to receive and retain the filling.

Opening the Orifice.—The mode of opening the orifice of any cavity depends largely upon the inward direction of the progress of the decay. When the carious action commences in a fissure, it attacks first the dentine at the deepest part, scarcely affecting the sides of the fissure, the consequence being the early production of a cavity having a relatively large interior and a restricted orifice. The appearance of this condition is represented by Fig. 49, which is a section of a tooth showing a sulcus in the enamel, at the bottom of which the dentine has been attacked, thus leaving the enamel to project over the margins of the cavity in the dentine. This is a type of ordinary simple coronal cavities. When, on the other hand, the decay commences on the surface of the enamel in the interstices between the teeth or upon the labial surfaces, an opposite form is generally first produced, the direction of the softening being obliquely inward, thus making a cavity which is obtusely conical. This is represented by Fig. 2 at *a*, where the enamel presents a considerable area of destruction at a stage when the dentine is only beginning to be acted upon. At length, however, similar cavities to this, as they advance, become so extended inward and laterally as to acquire the same relations as obtain in the first-named division, where the interior dimension is also greater than the outer. This is represented at *b* in Fig. 50.

Fig. 49.

Fig. 50.

As one of the purposes of the procedure now under consideration is to render the cavity so accessible that all the subsequent steps may be accomplished as far as possible by direct effort, the manner of opening each case is qualified by its position in the mouth, the part of the tooth affected, and the extent of the caries. The tissue involved in this cutting is usually the enamel: it should be removed so freely at the proper parts and in the correct direction as to allow easy access to every portion of the cavity. In addition to this, all weak walls and overhanging portions of enamel liable to be impaired in strength by the process of filling, or which may be in danger of being broken down at some subsequent time by the force of mastication, should be removed. It is obvious that when the enamel, unsupported by the nourishing influence of the subjacent dentine, is subject to the application of direct force, it must at length yield to this force, causing injury to the tooth and impairment of the filling. In many instances also when the borders of projecting enamel are strong and of excellent structure, although not in danger of fracture, it is inadmissible to permit them to remain, because of the impracticability of properly packing gold or tin beneath them.

There remains to consider a further reason for enlarging the orifice of the cavity to near the interior dimensions. As the filling material undergoes consolidation, if the sides are divergent the gold tends to withdraw from the margins, which, by so much as this has taken place, makes the filling deficient at an important part.

The removal of the margin of enamel and the opening of the orifice is effected by various forms of chisels, and in some instances by rotating burred drills.

The Chisel is one of the most important instruments at present used in the first stages of the preparation of cavities, it taking the place of files and drills, which formerly were much employed for this purpose. The advantages of the chisel consist in the facility with which it can be used to cut at whatever part requires removal, without the danger of cutting parts not needing removal; the enhancement of the comfort of the patient; and the promotion of the speed of the operation.

The cutting of enamel in opening cavities is performed by two methods—viz. by splitting on the line of cleavage of the enamel-prisms, and by planing, which is most easily done by a movement somewhat oblique to the line of cleavage.

The first method is performed when it is required to remove considerable portions of weak borders, and when channels of approach to give access to the interior of cavities have to be formed. The latter method is followed when small portions need cutting away to modify the formed spaces, to remove thin edges of enamel as in front teeth, and to countersink the margins of cavities.

It is to be observed that, however good the instruments for enamel-cutting are, they will not cut dense enamel directly across its fibres, but are used to cleave and pare it in the direction of the axes of the prisms. This is done by making short and quick successive impingements with the edge of the chisel very near the margins, or, when the enamel is soft or of medium density, by bearing the edge of the instrument against the orifice at such an angle to the margin as will force the edge to cleave away in successive portions.

The instruments for this purpose require to be of the best description, which rarely has been the case; and for this reason one of the most important means of facilitating the process of preparing cavities has too often been defeated.

The quality of the steel of which these instruments are made should be the very best, and the greatest care should be taken in every step of their manufacture, as no amount of skill will enable an indifferent chisel to do its work properly in cutting enamel. The hardness should be nearly extreme, and is best attained by hardening in oil, without any subsequent reduction of the temper. Some qualities of steel permit a greater degree of hardness by being plunged in cold water, the temper not being afterward reduced. Those who make their own instruments or have them made under their personal care will observe that the steel should be new, as any previous working may have done some injury to the quality. It should be selected of suitable size, be carefully and well annealed, and hammered while cold into the ultimate form. It is better that the face side of the instrument should not be filed away, but

retained as nearly as possible in the state of condensation and arrangement of fibres made by the hammer. If then hardened as above mentioned, a satisfactory result will usually be secured.

Chrome Steel.—Some years since chrome steel was put in use, and it has some advantages which render it suitable for this class of instruments. Chisels made of it are stronger than those of carbon steel, and can therefore be made much thinner, which lessens the labor of reducing them to sharpness of edge. They are stiff enough for free use at No. 26, American standard gauge,[1] for cutting between the front teeth and the bicuspids. Another advantage of chrome steel is that the edge is retained for a very long time, correctly tempered chisels often remaining sharp after several days of frequent use. This steel in reduction to small forms bears heating much better than carbon steel, as it may be forged at a heat which would ruin the latter. In hardening it, on the contrary, it should be chilled at a much lower heat than is required for carbon steel. The tempering for chisels and larger cutting instruments should be only very slightly reduced. Although it has been denied that chrome steel possesses any advantages, it has certainly proven to possess superior qualities for enamel-cutting.

FIG. 51. FIG. 52. FIG. 53.

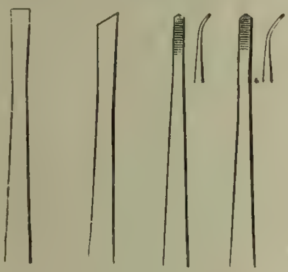
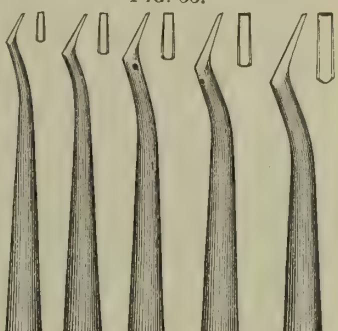


FIG. 54.[2]

The form of the edge of chisels depends upon the manner of use. When the enamel is to be cleaved, the grinding should be at an acute angle nearly to an edge to give clearance, and then an angle of 70° to 80° should be given to the cutting margin. When the enamel is to be planed, the edge should be less thin and the cutting margin should be 80° to 90°, the latter being generally more satisfactory, as either side of the instrument may be used at pleasure.

FIG. 55.



The forms of chisels must be various to meet the different requirements, and here, as elsewhere, a few excellent points of each kind will be of more service than many not so good. The accom-

[1] For size, instruments will be gauged in this paper by the American standard wire gauge.

[2] The blades of Nos. 41–44 are represented much too long.

panying figures (51 and 52) show the straight hard bits first devised by Dr. Arthur. They are intended for planing with their sides and for grooving with their corners. Fig. 53 shows bent forms intended for countersinking. These should generally be not thicker than No. 22. The forms shown at Fig. 54 are quite thin, and extremely useful for paring down the enamel between the teeth when the spaces are small; for cutting near the necks of the bicuspids to reduce them at this part when necessary; and they are also employed in trimming gold along the margins during the finishing process. The thickness of the straight-sided ones is about No. 26; the bent ones may be thinner. These forms are intended for planing.

Fig. 56.

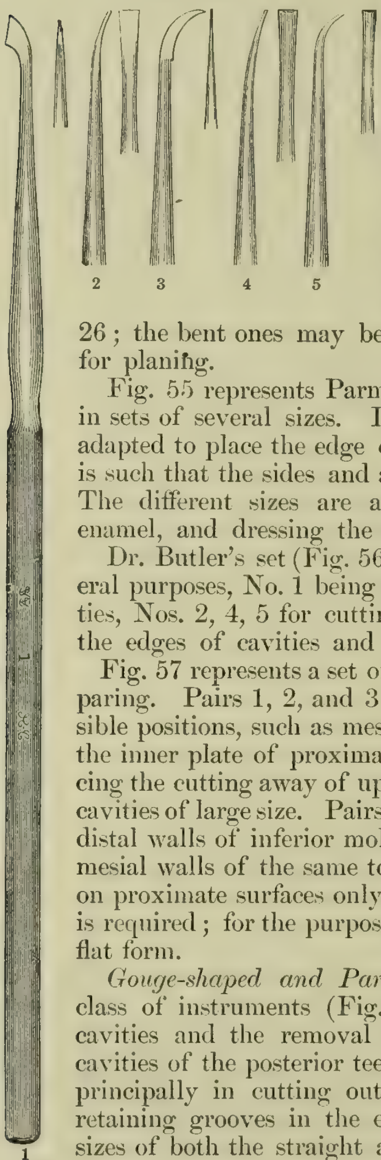


Fig. 55 represents Parmley Brown's chisel. This is made in sets of several sizes. It will be observed that the shape is adapted to place the edge on a line with the shaft. The form is such that the sides and also the ends are capable of cutting. The different sizes are adapted to opening sulci, trimming enamel, and dressing the cervical walls of cavities.

Dr. Butler's set (Fig. 56) is also admirably adapted for general purposes, No. 1 being used for opening large coronal cavities, Nos. 2, 4, 5 for cutting margins, and No. 3 for scraping the edges of cavities and trimming beneath the gum.

Fig. 57 represents a set of heavy chisels used for cleavage and paring. Pairs 1, 2, and 3 are generally useful for easily accessible positions, such as mesial and distal surfaces of bicuspids, the inner plate of proximate incisor cavities, and for commencing the cutting away of upper coronal walls of proximate molar cavities of large size. Pairs 4 and 5 are for paring away the inner distal walls of inferior molars, and pairs 6 and 7 for the inner mesial walls of the same tooth. This set is adapted to cutting on proximate surfaces only, and is intended when heavy cutting is required; for the purpose the handles should be large and of flat form.

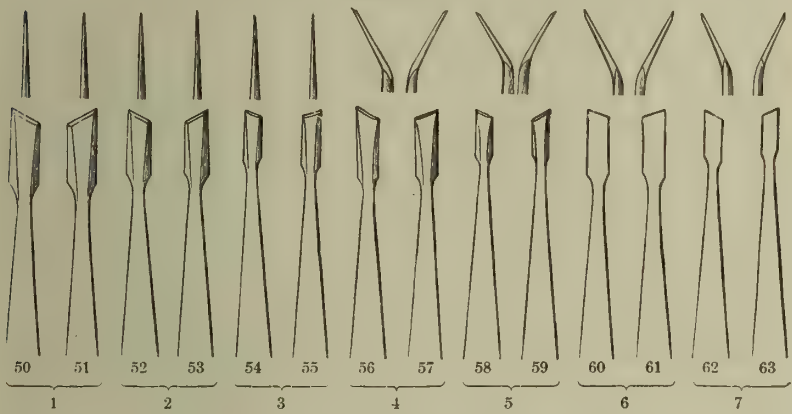
Gouge-shaped and Paraboloid Chisels.—The use of this class of instruments (Fig. 58) is for the opening of coronal cavities and the removal of the coronal plate in proximate cavities of the posterior teeth. The paraboloids have their use principally in cutting out the ends of sulci and in cutting retaining grooves in the enamel. They should be of several sizes of both the straight and the bent. The introduction of the dental engine has, however, lessened their usefulness.

One form of gouge-chisel, Dr. Wetherbee's (Fig. 59), is an absolute necessity in opening large cavities. It will be observed that the arc of the circle is large. The advantage of this shape is that the edge when

applied, if the instrument is of proper temper and quality, is certain to bite, whereas the flat chisel often fails to cut if the slightest inclination out of the line of the face of the instrument to the work is given to it. These gouges should be of various sizes, and as, on account of their form, they may be made very thin if of chrome steel, they are easily kept sharpened, as the amount of material is small.

The varieties of chisels which have been introduced are so endless that the reader would be wearied by a description of them. The matter of

Fig. 57.

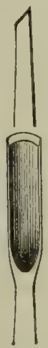


the greatest importance in connection with this class of instruments is that they should be of the best quality procurable, since those of inferior steel or of soft temper and poor workmanship are absolutely worthless for the purposes for which they are intended.

Excavation of Caries.—When the opening and definition of the cavity has been properly performed, the removal of the disorganized dentine is easily effected. It should be done with a light hand by means of thin and very sharp-bladed instruments. In this respect great care should be exercised in the selection of suitable instruments, those supplied for this purpose being usually too thick and clumsily formed, and are often improperly used for both excavating and shaping the cavity. The blades should be insinuated where the greatest disintegration of the decalcified structure has taken place, and the layers of caries quickly peeled away, the movement being toward the lateral margins.

Fig. 58.

Fig. 59.



In the coronal and all cavities of direct access the excavators may first be swept around the margins immediately beneath the enamel, when the remainder of the decay may easily be removed. When the cavity is on a proximate aspect, the excavator should be applied at first to the caries near the cervical wall, beginning at the middle portion and cutting toward the lateral walls. As soon as the decay is reasonably well

cleared from this portion, it may be peeled off the remainder of the cavity by lightly drawing the excavator toward the coronal surface. It is important that the instrument should be inclined toward the margins to avoid the pulp.

If the cutting be made downward into the cavity, a needless amount of suffering may be inflicted, as cutting by pushing the instrument excites a far greater degree of sensibility than is caused by draw-cutting. If it be attempted with dull and blunt-edged instruments, a greater torture is caused; whereas, on the other hand, if the foregoing precautions are taken, this portion of the operation should be nearly painless.

The removal of caries should always be made with caution and with reference to the probability of the proximity of the disease to the pulp. This caution is in the interest and for the comfort of both the patient and operator. In many instances the pulp is unusually near the periphery of the teeth, and not unfrequently the cornua appear to be extended outward beyond the usual limits. For these reasons it is important to give that organ the benefit of any doubt, and in the treatment of each case have in view the probabilities of exposure. In most cases it is necessary to remove the whole of the fully disorganized carious matter; but in instances where there is dangerous depth of the cavity it is allowable to permit partially decalcified dentine to remain, since this is capable of becoming recalcified, and if disinfected is probably incapable of exercising any deleterious influence. The preponderating weight of experience and of investigation has established this as the safest and most judicious course to pursue.

After the caries is excavated it may be found necessary to further remove portions of the enamel at the margins to maintain the correct relations of form. This is often required in treating interstitial cavities of the posterior teeth, and more particularly so at cervical margins.

The forms of excavators in use are multitudinous: they are, indeed, too much so, since a few forms if of good quality will reach the caries of any cavity if the opening has been correctly formed. One of the distinguishing characteristics of manipulative ability is the facility with which the hand may adapt the simpler forms of instruments to the various exigencies as they arise.

An important feature of the cutting edge of nearly all excavators is that the line of the edge should be a segment of a circle. The advantage of this is that the instrument cuts with greater keenness and produces a smoother surface of the bone. The general tendency also of a point of this form is toward the production of concave surfaces. It also lessens the danger of wounding the pulp.

Fig. 60.

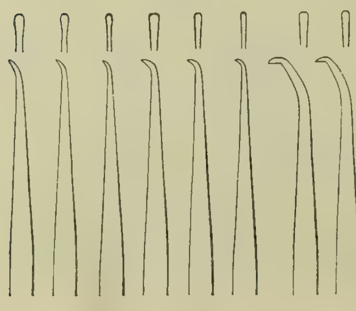


Fig. 60 represents a number of forms which for general purposes are sufficient. Dr. Corydon Palmer's original set of

six forms meets, in the most satisfactory manner, the wants of those who operate by the direct method, and when of the best quality they are exceptionally well adapted. A few special forms of excavators will be given in the course of this paper in illustration of the text.

The Artificial Formation of the Cavity.—The formation of the cavity to receive and retain the filling material, which is the next step in the preparation of a case, is governed by many considerations which cannot be made to appear in proper illustration except during the description of individual cases of cavities; each class having their limitation of form, place, and environment. In general terms, however, the sides of all cavities in which reliance is placed for the retention of the filling should for a certain distance inward be nearly transverse to the plane of the general face of the intended stopping, and should have an inward divergent direction. These sides in many instances are afterward grooved to ensure retention. When admissible, the retention-grooves should extend to all portions of the boundary; and this is usually possible except when, on account of excessive loss of structure, it becomes necessary to restore the tooth-form by building out the filling material, for which purpose special means will be later described. The process is then effected by means of retaining-pits as well as grooving. Retaining-pits, when adapted, should be placed in the stronger parts of the dentine, and care should be exercised to avoid proximity to the pulp. They are, however, less satisfactory as a means of retention than grooves, but are of service as aids in starting the gold. Grooves should be of sufficient depth to grasp the gold, and the axis of direction of those opposing each other should be inclined toward a plane perpendicular to the general face of the intended filling.

Countersinking.—When the shape of the borders of the cavity to carry out the plan of the filling has been secured, and the assurance is reached that the margins have integrity of structure at all parts, the edges should everywhere be slightly countersunk. The purposes of this procedure are—1st, to protect the margins from injury during the introduction of gold; 2d, to restrict the subsequent dislodgment of lacerated enamel-prisms; 3d, to facilitate the more perfect closure of the orifice of the cavity. It should also be stated that a fourth object is to permit the extension of the gold to the outer limits of the surface of the teeth in the case of cavities of the proximate surfaces of bicuspids and molars, and sometimes also of the incisor teeth, with the view of protecting the tooth-substance from contact.

The first consideration is so obvious that it scarcely need be stated that when force is made against an acute corner of any substance capable of being checked, this force may fracture the edge and produce a serrated margin. In many instances the pressure of the gold alone is sufficient to do injury; and while the directions given for packing gold do not permit the immediate touch of the instrument, it is not always possible to prevent this. When the margin is countersunk the ultimate expression of the pressure is made within the extreme margin.

The second consideration is one of much importance. Wherever a margin of a cavity is situated on a convex surface, the terminal edge of

the cavity is liable to be composed of triangular sections of enamel-prisms, which are represented in Fig. 61. When this relation exists, the danger of marring the edge is increased, and even in case the filling is inserted without harm to the enamel margin, sooner or later the triangular sections will follow their inclination to escape and leave a more or less ragged edge at the junction of the gold, instead of a sharp and clearly defined one. There will then be formed an irregular soiled crevice, into which a fine instrument may be inserted. The principle which underlies this is, that enamel deprived of the nutritive support of the subjacent dentine is liable to easily become disintegrated.

FIG. 61.

At *a* is shown the continuity of the margin by a direct line to the surface of the enamel at a convex part. At *b* is shown the line bent to conform to the direction of cleavage.

The third consideration is a purely mechanical one, and will bear some illustration. It has already been intimated that if the cavity were formed of sides having lines converging inward, the ability to fill all its parts perfectly and secure the greatest condensation would be greater than if these lines were either parallel or divergent. Generally, over some considerable part of the margins of the cavity the lines are necessarily somewhat divergent, for reasons already stated. The natural tendency of this slight divergence is toward the production of less solidity at this part or of an infinitesimal space there. The immediately succeeding convergent form of the orifice reduces this liability, and tends, as before shown, to the production of a dense surface and complete contact of the filling material with the edge. There is also a feature of packing gold, which will receive attention farther on, that has an important bearing on this subject—viz. the tendency of all forms of gold to draw away from the margins unless counteracted by the manner of applying the force used.

The degree of cutting to produce the required form to the countersunk portion is inconsiderable, and the form varies from the mere removal of the acuteness of the edge to an extension of the convergent line to as much as the thickness of the enamel.

In general, on coronal surfaces countersinking should be deep and not wide; on proximate surfaces of bicuspids and molars, slight at the lower portion and increasingly wide and deep as the coronal surface is approached. When cohesive gold is to be employed, the countersinking should be deeper and wider than when non-cohesive gold is to be used. The best means of effecting the cutting for this purpose in coronal surfaces is by burrs in the engine, either the small bud or the sides of the fissure-drill; for the labial and buccal, the edge of a small straight enamel-chisel; for the proximate surfaces, slightly curved, thin enamel-chisels. For the margins of cavities wherever there is accessibility small corundum points form admirable means of cutting, and at the same time they leave the surfaces quite smooth.

The concluding step in the formation of the cavity is polishing the edges, which is effected by means of suitably formed pieces of wood armed with pulverized pumice. In some instances it is well when there is complete control of the filling material to polish the whole interior of the cavity. The object of this is to facilitate, by a reduction

of friction, the movement of the gold while going into a state of condensation; in addition, a closer junction between the material and the margins can be effected, and the whole operation will have a more finished appearance, because of the greater density and the smoothness of the marginal line, if this line be neatly formed and well polished.

The foregoing general statements will appear more clear when their application is made to each general class of cavities, which will next be taken into consideration.

Decayed cavities in the teeth may be all included in three general divisions:

I. Those where there is easy and direct approach to all parts of the cavity, and where the cavity is bounded by an unbroken wall, however regular or irregular the outline may be. These are the cavities of coronal, buccal, labial, palatal, and lingual surfaces.

II. Those where the approach is more or less indirect, and when they are so situated that the instruments used for preparing and filling them cannot be applied at any desired angle to the margins. This division includes all the cavities of the proximate surfaces.

III. Compound cavities, which are produced generally by the union of two of the previous divisions, which is effected by the extension of the caries until coalescence occurs.

The principal modifications of each division are caused by the extent of the decay, the weakened margins, and the condition of extreme sensibility often accompanying dental caries.

Class I.—For systematic description this class is subdivided as follows:

a. Defective Sulci;
b. Coronal Cavities;
c. Labial and Buccal Cavities;
d. Palatal and Lingual Cavities.

a. Defective Sulci.—Caries of the coronal surfaces is sometimes induced by defects of structure, such as deficiency in hardness of the enamel, but more commonly by the existence of open sulci. But for this latter cause decay of coronal surfaces would be extremely rare, for the reason that the constant friction to which these surfaces are subjected is sufficient to protect them from carious action. The size of these fissures gives some indication of the quality of the teeth, and determines somewhat the choice of material to be used and the probable tendencies to decay, since when large and open they are coincident with other unfavorable conditions.

As has been previously stated, it is important that the presence and extent of the sulci should be determined in the commencement of the treatment of each mouth. They should be filled as soon as the least evidence of softening has taken place, which is determined by a peculiar darkening and raggedness of the margins, as well as the presence of sensibility. It is good practice in some instances to open the sulci of the molar teeth even before caries has commenced in them; and this is easily done with gouge-like chisels. The depression so formed should be polished with suitable substances, after which the attrition of mastication maintains the smoothness of these surfaces. This operation is

most frequently applicable to the inferior molars, where it is a very successful one if performed sufficiently early. Occasionally it may be applied to the upper molars, but never to the bicuspids, for the reason that it would deepen the fossa between the cusps to a dangerous degree.

This method is not often carried out, for the reason that close observation is not usual before caries has begun. When performed early and thoroughly, no similar operation is more satisfactory. But it should be stated that it is only in teeth of good structure, where the fissures are not deep and extensive, that the caries has not passed to the point where the necessity exists for more extensive cutting and the introduction of a filling.

Preparation of Sulci for Filling.—In cutting out the sulci the opening should be extended until it includes the extreme limits of the fissure, and the ends of the excavation should be made round, so that the stopping material may certainly make a perfect closure; which might not be secured if the extreme end be angular. The instruments well adapted for this purpose when the fissures are large are small curved chisels (shown at Figs. 7 and 8), with which to commence at the larger central part, the further excavation being conducted with a suitably sized fissure-drill. This instrument when rapidly rotated is more satisfactory than any other, possessing the advantages of cutting speedily, of producing parallel sides to the groove-like cavity, and of following the defects of the structure to the limitation of the defective part of the enamel. For reasons which have been stated the highly-speeded instruments do not cut enamel readily, unless it be either quite soft or is of defective structure.

When these small cavities are prepared in this manner, where there is slight destruction of dentine, but little further is needed after these simple steps than to countersink the margins by slightly scraping them.

The sulci of the bicuspid are usually formed of two pits joined by a narrow and often imperceptible line, in the latter part the caries being delayed; but this should in all cases be cut through and joined to the opened pits. (See Figs. 14, 15.)

The sulci of the posterior fissure of the upper molars is also imperceptibly connected with the sulci of the palatal face when this exists, and should either be connected or grooved out according to the indications of depth or of disintegration. In a similar manner the coronal fissure of the lower molars is connected with a sulcus on the buccal surface, and should be treated in the same manner.

Finally, it is important that the sulci be thoroughly prepared at an early stage of commencing disintegration. These defects are unfortunately too frequently neglected until there is produced considerable destruction of the subjacent dentine, causing weakening of the masticating surface at a part where the greatest strength is needed, and leading to serious consequences if the tooth in its future should be attacked by caries on the proximate surfaces.

b. Deep Coronal Cavities.—The deeper cavities of coronal surfaces are nearly always an extension of caries which has commenced in the bottom of a sulcus, and which has either been neglected by the patient or overlooked by the dental adviser. They are of great

variety of extent and form. They may not have advanced widely or deeply when the teeth are hard, or the carious action may have extended so much as to have destroyed the bulk of the dentine of the crown, leaving only a shell of enamel. In some instances this remains intact until a later period, when it suddenly breaks in, revealing the great loss of substance.

The form of the cavity may be simple when the decay is slight, and then but little cutting is required to place the cavity in readiness for filling; or, on the other hand, it may be of very irregular shape, and require considerable time and skill to make the preparation.

While fillings of this class are the simplest in all their stages, it is none the less important that they be performed with care. As from their situation coronal fillings are exposed to the shock of mastication, certain precautions have to be taken to ensure their durability. The margins of the enamel must be strong, and when weakened should be reduced in height, and afterward restored with the filling material. All radiating lines and angular depressions of the outline should be followed to their terminations, and so shaped that the filling may be easily forced into these parts.

The first step is to split down with chisels the unsupported enamel at the central part, until the orifice is nearly as broad as the interior, when the excavation of the softer caries may be effected. At this stage, if there is presented any evidence of the existence of sulci, they should be opened out to their ends, as previously described. This step is an important one, since if any fissure, however small, be permitted to remain, the filling will ultimately fail by decay commencing at this point, and ultimately undermining it.

FIG. 62. FIG. 63. FIG. 64. FIG. 65. FIG. 66.

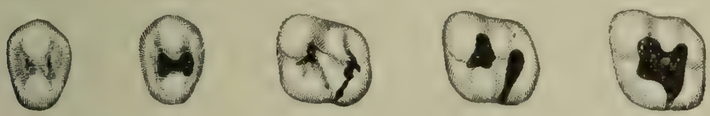


Fig. 62 represents the sulcus of the upper bicuspid, and Fig. 63 the same tooth after the preparation of the cavity. Fig. 64 shows the form of the sulci of the first superior molar, and Fig. 65 the same tooth after the preparation of these fissures. This figure represents a medium-sized cavity; when they are smaller, the form of the cavity is similar. Fig. 66 represents a cavity in the same tooth after the caries has advanced so much as to undermine the ridge of enamel between the sulci, when it becomes necessary to cut this ridge away and give the cavity somewhat the shape represented.

In following out the sulci connected with coronal cavities it is unnecessary, as has been sometimes recommended, to extend their depth to that of the larger part of the cavity. To do this causes an increased size of the cavity and a needless weakening of the tooth. Neither is it proper to much enlarge the breadth of these fissures, since the removal of any sound substance from this part of the tooth lessens its capacity to endure the perils to which the masticating teeth are subject. This state-

ment is made to counteract a too widely spread inclination to cut cavities into open forms simply to facilitate ease of manipulation.

The same objection may be found to attempts to reduce the floor of the cavity to a state of flatness. If the general form of the bottom of the cavity is concave, it is more easily filled solidly than if it is cut away to extend the sides in a perpendicular line to the bounds of the deepest parts of the cavity. If the perpendicular part is no deeper than the thickness of the enamel, it is sufficient, providing the gold is solidly packed.

The retentive form of coronal cavities is easily effected by the direction of the instruments during the cutting of the margins of enamel, in large cases it being necessary to leave only slight projections at at least two sides, while in smaller cases the wheel or oval-edged burr applied a little within the orifice will make the required groove. As the application of force is very direct in packing coronal cavities, and as the force of mastication is not calculated to displace these fillings, it is not important to more than slightly undercut them. The countersinking is best done with corundum points when the teeth are hard, and when soft by bud-shaped burrs.

The typical form of a coronal cavity to enable it to be solidly filled would be like the accompanying outline (see Fig. 67); but as the filling would not remain in place, it becomes necessary to alter this form to enable it to grasp the material. This is effected by making a groove around the cavity slightly within the margin. (See Fig. 68.) This groove need not be extended all around the cavity in all cases; neither is it necessary that it be deeply cut, but to effect its purpose it must be well defined.

Fig. 67.

Fig. 68.

The shape of the cavity beneath this may have its natural outline, the better if it be concave, since while for obvious reasons it may be more difficult to commence the filling, it will be more certain to be made compact and to be in perfect adaptation.

c. Labial Cavities.—These cavities, situated on the front teeth, including the bicuspids, are usually near the margin of the gum, and frequently extend to the cementum beneath the gum. They are generally shallow, and are usually exceedingly sensitive. Before the introduction of the rubber dam these were the most difficult cavities to properly fill, because of the extreme difficulty of preventing the encroachment of moisture. In many cases the extension of the cavity upward caused the gum to be wounded and bleed at any touch of the instrument, thus necessitating its being forced or cut away.

The preparation, except for the sensitiveness, is simple, but as it involves the face of the tooth, considerable care is needed to procure a neat and sightly outline and to avoid any marring of the surface of the enamel. It is generally better to make the application of the rubber dam a preliminary step, with a view to pushing the gum out of the way, and also to enable the sensibility to be relieved, after which the bulk of the cutting may be done with the rubber in position. The dam should include at least three teeth, and the ligature be well secured, with the

free end held upward, either by an assistant or a weight, with such a degree of force as may expose the cervical margin of the cavity. By this device and method these are placed among the simpler cases.

The cutting of the enamel margins is done with small chisels or the wheel-burr, and is extended until the normal enamel is reached. At the cervix the cutting should usually be carried up to the cementum, but in case there is a boundary of healthy enamel between the cavity and the gum, this should by no means be reduced beyond what may be required to secure a sound margin. This is obviously necessary to reduce as far as possible the disfigurement of these prominent surfaces.

Where the cutting of the margin has been made with the wheel-burr, the resultant form is nearly sufficiently retentive. When the cavity is small a pit should be made at each lateral side, and when broad a shallow groove should extend all around the margin. The floor of these cavities should be flat in its longitudinal direction, but in the lateral direction may correspond to the general outline of the tooth. If the cavities have considerable area, to deepen them to effect flatness of the floor in both directions would endanger the pulp.

The countersinking should consist in merely polishing the margin, which should be neatly and smoothly cut, as a clear definition of the edge of the filling is exceedingly important in these cases. This depends entirely upon the careful preparation of the enamel.

Buccal Cavities.—The preparation of this class differs little from that just considered. There are two descriptions of buccal cavities—those occasioned by the enlargement of a sulcus, which happens in early life; and those caused by caries at the margin of the gum, usually induced by the retention of food or sedimentary matter at this point. The former are extremely simple, and are treated like the coronal fissures. The latter are rendered difficult by their location, they being complicated by the interference of the cheek and by some indirection of the position.

The enamel margins are best prepared by the use of suitable chisels and smoothed by burrs. The sides should be transverse to the flat floor, and should be well undercut to facilitate the insertion and retention of the first pieces of the filling. The rubber dam is also frequently required here, as in labial cavities, the clamp being substituted for the weighted ligature.

d. Preparation of Palatal and Lingual Cavities.—The usual situation of these is inside the incisors and the molar teeth. These cavities most commonly occur in the upper lateral incisor. The sulcus of the palatal face of this tooth is dangerously situated in relation to the position of the pulp, and is frequently deep even when the external indications of decay are trifling. For this reason the fissures of these teeth should be filled at the earliest indications of the presence of decay, great caution being necessary to prevent needless exposure of the pulp. The direction of the drill should be nearly parallel to the axis of the tooth, and this instrument should be used only to open the orifice; this being done, the removal of caries is better accomplished with small, thin, round-ended excavators.

The usual situation on the upper molar is at the seat of the fissure

found at that part; there it is treated as a simple cavity, but when caries occurs on the lingual surface of the inferior molars it is more difficult of treatment, on account of the inclination inward of the teeth and of the interferences of the tongue. The pulp is also close to the surface at this portion of the tooth. The instrument most suitable for the cleansing and formation of the cavity is the wheel-burr in the right-angle attachment. By the aid of the rubber dam these cases can be readily prepared. They are generally better filled by some of the plastic materials, especially when they occur in the second or third molars.

Class II. Preparation of Cavities of Proximate Surfaces.—The inclination to proximate caries of the teeth has its inception in somewhat different predisposing causes from those which generally induce caries of the previous class. In the former, the sulci, being open fissures, become filled with the finest portions of the food, which, being impacted there, undergo fermentation when favored by suitable chemical conditions of the oral fluids, and thus cause considerable decomposition in advance of caries of the proximate surfaces. While there is some analogy between a fissure of the enamel and an interstitial space, there is this physical difference—that the fissure has roughened sides and is wider at the bottom than at the surface, and thus is retentive of its contents; while the interstitial surfaces are smooth and smaller at their central portion, causing greater opportunity for the movements of the lips, cheek, and tongue to displace the contents of the space; hence the progress of caries at the earlier stages is slower. The law finding expression here in the limitation of the progress of decay is universal in its action in all cases of proximate caries.

This is an opportune place to call attention to certain peculiarities of proximate decay with reference to its immediate practical application to the treatment of interstitial caries. It has long been observed that the point where caries begins on these surfaces is not where the teeth are in exact contact, nor where they are considerably apart, but at the point of close contiguity. In the front teeth the decayed spot is at first round, in the bicuspids oval, and in the molars it is an oblong, narrow line rounded at the ends and frequently narrowing at the centre of this line. The cause of this has been laid down heretofore in this work on grounds which are clearly defined and indisputable—that it is due to this being the point of least agitation of the interstitial fluids; that the products of fermentation of the mass of sediment near the gum are retained here longer than elsewhere by the force of capillary attraction, for the reason that the space at this point is the smallest.

The apparent exceptions to this law are exhibited when cavities occur at the cervix of the teeth, but these cases are attended by an unhealthy state of the gums, and not unfrequently two cavities are formed simultaneously on proximate surfaces—one at the point in question, and the other at the neck. The bearing of this law upon the treatment of caries is one of considerable significance, and will be frequently adverted to in the course of this paper. From this point, after softening and disintegration of the enamel has taken place to a limited degree, the decay proceeds inward until the dentine is reached, when the action extends more toward the cervical aspect of the dentine. The determination in

this direction when the teeth are of good constitution is very marked. When the teeth are of inferior character, this qualification is not so apparent. In this latter case the peculiar modification of the caries is in the direction of weakened margins and of threatened pulp-exposures. The result of the limitation alluded to is to produce cavities of the front teeth of marked triangular form, the base of the triangle being toward the cervix. This qualification appears to be attributable to the vital resistance of the tissue immediately beneath the enamel and of the dental fibrils which radiate immediately from the cornua of the pulp. These considerations throw considerable light upon the progress of caries, and assist in estimating the probable progress and direction of the carious action.

The limitation of the caries in proximate decay of molars and bicuspids is not so marked as in the front teeth, but the same principles govern the progress of the disease. These cavities usually have their larger part nearest the cervix. They are wider and deeper there than immediately beneath the part of the enamel where the inception of caries took place. This limitation of caries is a fortunate circumstance, for if it were reversed the masticating ends of the teeth would be the first destroyed, and the pulp would very early become exposed.

The form of the teeth on the proximate faces modifies the place where the initial carious point is situated. The teeth may be divided, for the sake of convenience in relation to their form, into two general classes—those which are large, of square shape, having parallel proximate sides which are in contact from the gum to their ends; and those which are of rounded shape, and having proximate sides presenting inclined surfaces to such a degree that spaces appear at the gum line. In the latter the carious action commences some distance from the cervix in agreement with the consideration just stated, but in the former much nearer the gum; and as the general space is smaller, capillary force is greater throughout a larger part of the space, hence the size of the spot of softened enamel is considerable. The treatment of such teeth is more precarious throughout, inasmuch as this form is generally accompanied by softer structures, and if also attended by great disposition to caries, the probabilities of successful treatment are rendered uncertain. The latter, fortunately, are of a more promising nature, and reward the operator with better results.

The mechanical difficulties in the treatment of proximate cavities are very much greater than in those of the coronal surfaces. The approach, being less direct; the obscurity, when the cases are in the back of the mouth, for want of light; the effort necessary to keep away the muscles of the face during the operation; and the greater sensibility,—all conspire to complicate every step in the procedure. In addition, the manipulation demanded is of the most skilful nature, the opening requiring force, tact, and precision, and the excavation and formation of the cavity necessitating great care to avoid cutting parts which may weaken the tooth or make too close an approach to the pulp.

The treatment of these cases has its key in a consideration of the fact that the most of the preparation and the packing of the filling material must usually proceed from one general direction, and that an

oblique one. There is not the same liberty either to use the excavating instruments or to manipulate the material from all sides and to apply it along the margins, to effect that easy condensation and overlapping of the material so essential to sure success, as in the first class of cases. This inability partly accounts for the great number of failures which occur in the treatment of cavities on proximate surfaces, it being a notorious fact that a very large proportion of proximate fillings are imperfectly made from disregard of the greater care demanded by the enhanced difficulties.

The aim of this section will be to elucidate the means best calculated to overcome these difficulties, and to place the treatment of these cases on such an exact basis as shall be calculated to render their performance more certain. Toward this result dentistry has been gradually approaching during the past two decades. It might be said that previous to that time the proximate operations now being considered had been too generally performed in an aimless manner. If the teeth were of excellent quality, the results were, it is true, often preservative; but if of moderate or inferior quality, they were generally nearly worthless. This was particularly the case with the bicuspids and molars.

There is no gainsaying the statement that all the operations included in this class require much more than ordinary care. They cannot be performed in a routine manner and be followed by good results. The number of failures of these cases constantly occurring should arrest attention; they demand that care and thoughtful application be given to every step in each case. The important and durable results produced by many careful operators by means thoughtfully applied, and which are within the reach of all, place the question of successful attainment on a reliable basis.

The following subdivisions of Class II., with the included modifications, will cover nearly all the conditions which are usually observed:

Proximate cavities of incisors and cuspids;

Mesial cavities of bicuspids and molars;

Distal cavities of bicuspids and molars.

Small Proximate Cavities of the Front Teeth.—The cavities now to be considered are those of small size which have been detected previous to much decay of the dentine. To so treat them as to prevent their recurrence requires care, for it is a fact of general observation that failures are more common to minute fillings between any of the teeth than to larger ones in the same position. The reason for this will appear in connection with the subject of contouring. This misfortune, however, is not of such frequent occurrence in the front teeth as in the posterior ones.

The first step in the preparation of the cavity is to sufficiently separate the teeth by pressure, concerning which there is no difficulty in the front of the mouth, even when the teeth are firmly set and in the closest contact, since the teeth of the arch move outward when force is applied between them. The space should be at least No. 22 of the gauge, which may be increased at the time of operating by a wedge of wood. The definition of the margins is now made with thin enamel-chisels, with which the softened enamel is removed; at the same time a

small portion of the palatal plate of enamel is taken away to increase the approach and to permit some of the gold to be extended inward. This latter is one of the requirements necessary to prevent recurrence of decay, as well as to give access to the cavity.

The excavation next proceeds by means of very small excavators or small rose-drills in the engine. Nearly all the excavation should be effected from the palatal direction. If the cavity comes within the designation above stated, but little cutting will be required to make it retentive—a few touches with a very small excavator, similar to Fig. 69, along the face of the labial wall, the squaring of the cervical wall, and some slight grooving of the lingual wall with a very small wheel-burr, or better, if accessible to it, a very small point like Fig. 69. The countersinking should be slight, and the surface of the enamel should be smoothed with a tape and pumice.

FIG. 69.

Large Proximate Cavities of the Front Teeth, the Labial Wall being Intact and Strong.—These cavities, when presented of so extended a character as to have seriously attacked the dentine, usually cover a considerable part of the surface involved, the softening of the enamel having commenced early in life, during the careless and precarious period of childhood from the tenth to the twentieth year. The process of solution of these surfaces is often long continued, not attracting attention until the dentine has become carious. The seat of softening ordinarily is along the line where the teeth are in near contact, and is scarcely ever found at this stage at the point of exact contact, which is usually kept somewhat polished by the movement of the teeth against each other. The resultant carious spot is of somewhat triangular form, the apex being presented toward the cutting edge. At this point, as has been pointed out, the carious action commences in the dentine, and makes its greatest progress toward the cervix, widening as it advances, headway being made in this direction because toward the cervix the resistance is less than near the upper end of the tooth. The progress in the lateral direction is modified by the form of the tooth, and is qualified by a variety of conditions. This action reaches an advanced stage before the enamel toward the cervix breaks down.

The earliest step in the treatment is to make a sufficient separation by pressure, usually two thicknesses of tape, followed by some immediate wedging, being sufficient. The cavity should be approached from a direction which will enable it to be filled in all its parts with certainty, without disfiguration, and, if possible, without exposure of the stopping when finished. This direction is from the palatal aspect of the tooth, and is made easy by cutting down at the middle part of the palatal plate of enamel nearly to the apparent bottom of the cavity. This may be called the "channel of approach."

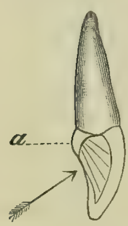
The palatal plate of the incisors is usually very thin, and is consequently extremely liable to be broken away in service if not removed during the operation. It is hence judicious to cut it away to a degree having reference to its thinness, its softness, and the size of the cavity.

The removal of this plate of enamel is easily effected by either gouge-chisels (Fig. 52) or such a simple chisel as 40 or 41 of Fig. 54, the point of which is principally used by giving it a slightly sweeping movement accompanied by some rotation of the hand. The soft caries is now removed by spoon-shaped thin excavators, when the case is ready for those modifications in the shape of the cavity necessary to secure the retention of the filling.

In connection with the usual forms of carious cavities an examination of the anatomy of the front teeth reveals an easy means of securing retention without endangering their strength, and in such a manner as to permit nearly direct action of the plugging instruments. As before stated, the cavity extends from the cervix to near the cutting edge, and is nearer the inner surface of the tooth than the outer. The consequence of this is that the labial wall curves enough in the lateral direction to produce a concave border on its inner surface; in other words, it tends to overlay a portion of the gold. This wall, then, is naturally retentive without grooving. It is, however, important in preparing the labial margin not to cut away the hard dentine which may remain at its base, it being better to proceed with a concave bottom to the cavity than to make it flat at the risk of weakening this wall. Opposed to this wall is the remainder of the palatal plate, which includes the tuberosity called the basilar ridge. Within this a retaining-pit and a small groove running from the pit to the channel of approach are made. This portion of the tooth is generally strong and permits sufficient undercutting.

The analysis of the retention will more clearly be seen by studying the annexed outline of the case (Fig. 70). The arrow shows the line of approach; *a*, the tuberosity; the lines drawn from *a* toward the labial wall indicate that a single well-formed pit at *a* will hold the gold against the whole of the labial wall as well as if the pit were a groove opposite to the labial wall throughout. The cutting at the cervical wall should be extended to the cementum, if it be at all near this structure, as it is unsafe to proceed with a narrow, thin line of enamel at this point.

Fig. 70.



This wall should be cut transverse to the axis of the tooth, and it rarely requires to be made retentive beyond this. If for any reason it is intended to fill the cavity entirely with cohesive gold, a pit should be made near the middle cf this wall, care being had as to the proximity of the pulp.

It is important that the interior surface of cavities, in front teeth in particular, be smoothly cut to secure the close contact of the gold with the walls. On this largely depends the perfection of finished appearance. The instruments to be used, therefore, should have rounded blades, which do not produce scratches in the dentine or enamel. The importance of this form to the cutting blades of excavators was first demonstrated by Maynard.

In the older methods the retention was made by undercutting at the cervical border and near the cutting edge, with what additional support might be found by grooving along the inner plate of enamel. It is not

difficult to demonstrate that these means of retention are not reliable, and that they may be injurious in some cases.

The dangers of making retention at the apex of the cavities are considerable. The plates of enamel approach each other very nearly at this point, and to cut sufficiently here to effect proper retention is liable to weaken them ; in addition, it necessitates cutting out the healthy dentine, which is usually remaining here in the cases under consideration. This weakens the enamel by depriving it of the support of the subjacent dentine, the result of which is that frequently the corner of the tooth becomes broken away.

Fig. 71.

27 28 91

Fig. 72.

183

The forms of excavators to remove the carious matter from these cavities are shown by Fig. 71, No. 91 being used for the labial wall and No. 27 for general use.

The retaining groove in the tuberosity may be made with small round hoes (Fig. 72) or by wheel-burrs in the engine, the cut being afterward rounded with the hoe. The countersinking should be slight except on the labial wall, where it is necessary frequently to bring the gold out to the line of the face. This line should be well polished.

Proximate Cavities of Front Teeth when the Labial Wall is more or less Deficient.—This condition is the result either of neglect combined with the most active state of the exciting causes of caries, or the failure of previous operations caused by injudiciously planned methods or by defective manipulation. In consequence of these deficiencies insidious softening of the interior surface of the labial plate has occurred. In some cases the loss of substance may have been the result of accidental injury.

In all such cases the cavities have to be prepared in a different manner from that last described, because in most instances but little support can be derived from the remaining part of the labial wall, since it is liable to be too thin and frail to permit of any undercutting. Dependence must be had upon the tuberosity, which, fortunately, is usually strong, upon the inner plate of enamel, and by means of a retaining-pit in the cervical border.

The Opening.—This should be preceded by a proper separation to enable correct cutting to be made and the proper formation of the filling to be effected : even when space is not needed to perform the excavation, it is required during the subsequent steps of the operation. The opening of the cavity is commenced by trimming the labial wall to a state of smoothness, permitting as much to remain as can be retained ; at the same time its sharp irregularities should be removed, in order that the line of gold when finished shall be in agreeable curves. The result of this cutting determines how much retention can be secured by this wall, and enables the subsequent means of retention to be planned.

As the lingual wall is always, even when comparatively strong, liable to injury from the impact of the inferior incisors, it is important to examine the nature of the occlusion. If the lower teeth do not strike

and the enamel be thick, nearly the whole of this plate of enamel may be permitted to remain; it is, however, in all cases necessary to remove some of it to permit the extension of the gold to the lingual surface, and thus prevent the contact of enamel with enamel at the margins of the filling. If this border be weak, it becomes necessary to cut it away, as described in the first class of front-teeth cavities, but not to the same degree, partly because the filling is not introduced from this direction.

The cervical wall is now cut down squarely as before, the cavity being extended to the cementum whenever practicable.

After the removal of the caries in the usual manner, the case is ready for its final formation. A pit and retaining-groove should be made in the tuberosity, a retaining-pit be cut in the outer third of the cervical wall, and whatever slight undercutting can be secured without weakening should be made along the base of the labial and lingual wall. In some cases the filling may be extended along the inside of the cutting edge, where a retaining-groove and pit may be made. The margins should be so formed as to nearly coincide with the line of cleavage, and at all points be slightly countersunk, then smoothly polished with powders.

Proximate Cavities of Front Teeth extending to Cutting Edge, the Labial Wall being Frail.—Sometimes in this class of cases so much destruction of tissue has occurred as to extend the carious action to the cutting edge. The treatment of the cases then becomes very tedious, difficult, and hazardous.

When the pulps remain alive the retention depends upon the depth of the cutting at the stronger and thicker parts of the tooth at the base of the cavity. No specific rules can be laid down to meet the varying contingencies which arise with each case. It may be stated, however, that nothing short of a complete restoration of form in these cases is acceptable, and when the amount of gold displayed becomes extreme, it is often a question whether some form of substitution be not better than a laborious restoration, which is peculiarly liable to destruction through use or the accidents to which the front teeth are subject.

Compound of Proximate and Labial Cavities near the Cementum.—This combination is not uncommon when a labial cavity has formed near the gum and has coalesced with the interstitial cavity. The preparation of each portion proceeds at first independently, up to the point where it becomes necessary to establish the means of retention. Thus far, the proximate part will be the same as before. The retention surfaces of the labial cavity, however, are made more pronounced, as they can thereby be rendered the means of a more certain retention of the proximate division of the filling, as the gold composing it may be so joined to and united with the other as to bind the major filling securely in place.

In doing this it is not necessary to cut down the floor of the labial cavity deeply, which might weaken the tooth, since if the proper kind of gold be employed depth of the labial division is not a necessity.

FRONT TEETH.—*Cuspids.*—The plan of treatment of the cuspids varies but little in its details from that for the incisors. As the teeth are pointed and more rounded, and as the force of occlusion is not applied to the lateral enamel margins, it is admissible and advisable to

cut more deeply toward the cusps to secure better anchorage. As the lingual plate of enamel is stronger and the border more projecting, it is not needed to cut away so much of this inner wall.

All the elements are simpler and retention is more easily established, and yet experience proves that fillings of the cuspid fail more frequently than those of the central incisors. This may be caused by the rounded form of the teeth on their lateral surfaces in the longitudinal direction, which occasion them to present a smaller triangular interstice, the cleansing process being thus restricted.

Mesial Cavities of Bicuspids and Molars of Small Area and Superficial.—Separations of the teeth for this division are required, but need not be so great as is generally needed for the front teeth. Occasionally, when the teeth are in close contact and the alveolar structures very firm, considerable difficulty is experienced in effecting proper separation of the back teeth. The most suitable substance is india-rubber, the resilience of which will nearly always accomplish this purpose. It is better to commence with a thin piece, and follow by the application of a thicker one. The pain and annoyance by this means will be much less than if the thicker piece were at once inserted. When the teeth are not very firm, the use of a thin piece of rubber, followed by cotton tape, is an excellent plan. This has the advantage of permitting the operation to be carried on without resting the teeth. In separating the teeth by pressure much judgment is always required to avoid giving needless pain and discomfort. In this respect there is great difference in patients, some tolerating continued pressure and free opening without complaint, and others being aroused to the highest degree of irritation by any application for the purpose. Some additional space can always be made by the necessary cutting which the softening adjacent to the carious cavity requires.

The former method of separating the bicuspids and molars was to immediately file them apart to produce a V-shaped space. This was done ostensibly to make easier the production of solid and satisfactory fillings, it being further urged that this space was favorable to the preservation of the teeth. As this subject will be discussed in the section in which the object of contouring is considered, only this reference will now be made to it.

The more acceptable method, which is now largely practised, is to secure access to the interior of the cavity by cutting away a portion of the coronal plate. This to some has not appeared equally as necessary in small as in large cavities, as by rather widely separating the teeth small cavities can be otherwise filled. It is, however, to be noted that the small fillings of bicuspids and molars which are filled in this manner, however well they may be done, are usually subject to early failure, for the reason, first, that they cannot be so well performed; and, second, that the teeth return to their former position, thus permitting caries to take place along the coronal border of the filling, if softening does not also ensue about the outer plate. So common is this result that no failures of tooth-stoppings are so lamentably common as the small fillings in this position. The result is not changed by the disfiguring spaces made by cutting, for so soon as the teeth approach each other the posi-

tion of renewed caries is transferred to near the new point of contact. When, however, the coronal plate is partially removed to the degree which permits the gold to appear across the proximate face at this part, the dangers of recurrence are much diminished.

The formation of the cavity can generally be done with a rose-drill, and the partially softened tissues at the cervix removed in the same manner. The cavities, being small, do not permit, as well as the larger ones, the employment of chisels. An important question here arises: How far shall the cavity be extended toward the gum? Some skilful and careful operators have been in the habit of carrying the cavity to and slightly beneath the gum, for the purpose of securing the protection to this margin which the healthy gum affords. When the teeth are of good structure, this is not always necesssary. Whether it shall be done depends upon the character of the teeth, the tendency to decay of the teeth of the individual, and also upon their form. If the teeth are soft and the carious tendency marked, the indications favor free cutting in this direction, for the reasons presently considered. But if the teeth be of good structure and the form of the proximate surfaces be well inclined from each other at the gum, such free cutting is scarcely necessary; but if the teeth are parallel-sided, there remains apparently but the one course to pursue if the object be to secure the assurance of permanent results.

It remains to consider the tendency to recurrence of caries along the buccal walls when these parts of the contiguous teeth are permitted to come into near contact after the insertion of the filling. The same relations and conditions which predispose the teeth to decay near the point of usual contact must have the same influence here. Consequently, it is important to open the cavity by cutting the buccal margin sufficiently to permit the gold finally to be slightly seen at this margin.

Dr. Perry in an able monograph upon this subject has enforced the necessity for this course as the only one which will increase the permanence of the work.[1] The retentive form is given by a groove in each lateral wall. These are formed by first drilling a shallow pit near the cervix, and are completed by cutting from the pit toward the cusps. These grooves are easily shaped by either a small fissure-drill started in the pit, or by small bent cutters shaped like Fig. 73.

Fig. 73.

Mesial Cavities of Bicuspids and Molars of Large Size.—The procedure in large cavities does not materially differ from that pertaining to the smaller ones of the same surfaces. The cavity, being larger, necessitates the removal of more of the coronal plate; the greater frailness of the lateral walls requires greater care to avoid weakening them. This is more particularly the case in the bicuspids. When the grinding surface is not broken down, the first step is to cut out in a triangular shape the coronal plate in the manner indicated by Fig. 74. This gives access to the interior.

Fig. 74.

The form of the proximate aspect of the lateral walls next requires

[1] *Dental Cosmos*, vol. xii. p. 562. Also, see the discussion on Contouring.

some particular direction. Calculation should be made at the outset to take advantage of all means which will assist in producing an ultimate free space at the neck of the filling. Whenever practicable, a little paring of the enamel should be made at this point. Generally, however, some cutting is required to remove softened enamel and to produce the assurance of integrity of this part of the tooth.

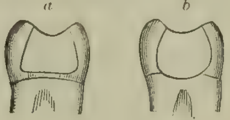
The preparation of the cervical wall requires more than the usual consideration. The failures of operations of the proximate surfaces of these teeth happen extremely often by recurrence of caries at the cervical margin of the filling. Why is this the case? It is a well-established fact that caries is less likely to occur at the neck of the tooth than at any other portion of the proximate surface. This being so, why after fillings are inserted is the liability increased at a part previously less liable? The general answer has been that it is attributable to defective manipulation. In what does this defective manipulation consist?

1. It may be caused by improper planning of this wall. 2. It may be caused by imperfect removal of caries. 3. The gold may be imperfectly consolidated. 4. The gold may be driven with too much force against this wall. 5. The filling may not be completely finished at this part. Here the first and second reasons only can be considered.

As the cervical wall is the base of the operation, its preparation needs to be conducted with the full view of the fact that the filling is to be built upon it, and that through a considerable portion of the packing the force used in consolidating the gold, by whatever means used, is expended against it.

The plan, therefore, requires that its surface should be cut transverse to the axis of the tooth. The outline should, when the nature of the case will permit, be curved throughout, and should meet the outline of the inner and outer lateral walls of the cavity by an easy rather than an angular curve. When this wall is so formed, the movement of the gold as it is packed tends by the plainest mechanical laws to closer apposition with the surface. This will appear by an examination of the two outlines *a* and *b*, Fig. 75. It will be observed that the cervical outline of *b* extends to the cementum. It is obvious that the same form may be given to *a* by extending the cutting downward in the same manner, which also gives the additional security of a base upon the cementum. The farther, within reasonable bounds, this cutting extends downward the greater will be the security from recurrence of caries, provided all the requirements of a good operation are fulfilled.

Fig. 75.



The instruments best adapted for preparing the central wall after the removal of the soft caries are narrow, square-ended chisel-like cutters. No. 3 of Fig. 55 represents a suitable chisel, or any instrument of square end and keen edge, having a single bend, will answer the purpose. These forms are such that the cut is transverse to the line of force. By altering the direction, these instruments may be used for shaping the margins of the lateral walls to make them continuous with the sweep of the cervical curves. This mode of cutting leaves the preparation

nearly complete, it remaining only to scrape the cementum beneath the gum.

In many instances, where the teeth are soft and where the contiguous gum has been inflamed during the carious process, the secretions of the gum, in this condition being acidulous, have acted upon the surface of the tooth beyond the cavity. Frequently, after all the preparations are supposed to be complete, when the cavity is thoroughly dried, the ultimate margin reveals by its opacity the absence of integrity.

FIG. 76.

Special instruments like Fig. 76 are adapted to scrape the surface of the cervix.

The outline of the margin of the buccal wall requires some special care. The same reasons for the extension of the gold over the margin to prevent the recurrence of contact are here equally operative as in the smaller cases last described. To do this efficiently requires that a portion of this plate be removed in the manner delineated in Fig. 77. This loss is afterward to be restored.

FIG. 77.

In cavities of moderate size the chief dependence for retention is by cutting grooves in the coronal plate, or by joining the anterior coronal fissure to the proximate cavity, as may appear most judicious. When there is no opportunity to groove the coronal plate laterally to secure binding of the filling at this point, the principal means of retention must be made in the cervical wall by means of pits and by grooving of the lateral walls. Wherever there is sufficient strength, some grooving should be done at these parts.

It is frequently necessary, after opening the case and removing the carious matter, to apply the rubber dam. This aids in various ways: it partly keeps the mouth restrained; the exclusion of moisture permits the reflection of light from the interior of the cavity, enabling all parts to be clearly seen; the surface quickly becomes less sensitive; and finally, if necessary, the proper obtundants may be efficiently applied.

The cavity during the preparation may be cleared of débris by damp cotton or the chip-blower. If it is desired to retain the same rubber on the tooth during the filling, the cavity should be thoroughly washed, as there cannot be full assurance that every particle of the débris has been blown out. This is facilitated by applying to the proximity of the orifice of the cavity a mass of soft bibulous paper, and when syringed the paper takes up the greater part of the water. The balance should then be absorbed by paper and the parts air-dried.

Distal Proximate Surfaces of Bicuspids and Molars.—These constitute in some parts of the mouth the most difficult and tedious cavities to prepare. The lower left bicuspids are probably the most easily operated upon of all the proximate surfaces, but after these no class make greater demands upon skill than the distal cavities, the situation and all the relations being unfavorable. It is, however, notable that a great advance has taken place in the treatment and the consequent success of serious fillings of the molars. This has been effected by the facility given by the removal of the coronal wall, which being, to some degree,

a benefit in the mesial cavities, is an essential and indispensable procedure of distal cases. When the lateral walls have sufficient strength to permit the solid packing of gold, the coronal wall should be cut away at the central portion to the bottom of the cavity. This opens up the interior of the cavity to the access of the usual instruments.

The removal of caries and the preparation of the walls are much the same as in mesial cases. Less dependence is placed upon the cervical wall, and more upon the lateral walls, for the retention. For this reason the security of the filling is made more complete by grooving the outer and inner plate, and by extending these grooves wherever admissible into the coronal sulci.

FIG. 78.

The instruments well adapted to grooving the lateral walls of small cavities are shown at Fig. 78. Small curved paraboloid gouges are also very useful for the same purpose for the larger cavities. In the use of these instruments care is necessary to so direct the blade as to avoid opening the pulp-chamber. To prevent this accident the elbow of the shaft should be held in impingement with the tooth at the opposite side of the cavity, which directs the blade somewhat outward. Fissure-burrs are often applicable to the bicuspids, and sometimes to the first molars.

FIG. 79.

The shaping of the cervical wall is here more difficult than in the previous division, and requires even more care than the same part elsewhere to place the surface transverse to the line of force in packing the gold. The direction should incline slightly inward by a divergent line. The outline should be curved rather than flat. The margin should be extended beneath the gum in all cases where possible. Finally, the surface of the tooth adjacent to the margin should be thoroughly scraped, as before described.

The instruments required for the preparation of this wall are such as those shown at Fig. 55 for the upper teeth, and for the lower ones the form represented by Fig. 79 (Dr. Pugh's pattern). These are in pairs, and are held in a vertical direction, the cut being made from the middle of the surface to the outer or inner wall.

CLASS III.—COMPOUND CAVITIES.—These are produced by the coalescence of two cavities or by the extension of a single cavity in such a manner as to include two surfaces of any given tooth. This complication, with one exception, much enhances the difficulties of all the procedures, and in all instances very much increases the labor and the time necessary to execute the case.

The divisions are—

1st, Proximate with coronal surface or cutting edge;
2d, Proximate with labial or buccal;
3d, Proximate with palatal or lingual.

Proximate Cavities and Cutting Edge.—These cavities are confined to the incisors, and do not usually occur until after middle life, this combination not being produced until by the friction of use the two plates

of enamel become worn to such a degree as to expose a line of dentine between them. In some instances the exposed dentine softens; in others it, being softer than the enamel, wears away, which necessitates that a groove be made and filled to protect the plates of enamel from being driven asunder. When this condition occurs in conjunction with a proximate cavity the point of juncture of the two cavities is the only one needing special illustration.

The preparation of the cavity of the cutting edge is after the manner of the preparation of a sulcus. Care should be taken not to reduce or to undercut the margins more than is absolutely necessary. The ends of the plates of enamel should be very slightly shortened, and countersunk to allow the gold to cover and protect the enamel, but in such a manner as not to come into view.

The preparation of the proximate cavity is as before described. The two cavities should be joined at the corner of the cutting edge in such a manner as to preserve the outer plate. As the inner plate is more liable to be injured by the inferior teeth, it is the common practice to cut away a portion of the inner corner, which is afterward restored with gold. The connection of the two cavities makes more easy the retention of the proximate filling, as that of the cutting edge when properly incorporated with the proximate gold gives security to the latter.

It is, however, to be noted that while both cavities require to be slightly undercut or pitted, as the case may demand, no undercutting of the outer plate near the junction of the two cavities should be attempted, as this inevitably weakens the outer plate and would lead to a loss of a portion of it. Therefore, the form of the interior surface of this part should be left as it appears after cleansing. If additional security is needed at this part, it should be obtained by grooving slightly the inner plate.

The instruments best adapted for preparing the cavity of the cutting edge and for the grooving is the small wheel-burr, which should be lightly held and kept in constant movement during its revolution.

The same methods apply when similar conditions of the cuspid are presented. This tooth, being stronger and less liable to injury than the incisors, requires less delicacy of handling. When, however, the cavities are large, the tooth should be somewhat shortened to prevent severe occlusion and to permit the shocks incident to the use of the cuspid to be met by the gold.

The preparation of similar cases of the inferior incisors requires an important modification of the above description. The lateral corners of these teeth are extremely frail, and are liable to be injured during the treatment. To prevent this, the grooving of the cutting edge should be omitted, and in its stead a single retaining-pit should be made at the middle part, at the junction of the inner plate and the dentine.

Proximate with Coronal Surfaces.—This combination is necessarily confined to the bicuspids and molars, and usually simplifies the performance of the proximate portion. As has been observed, the necessities of most proximate cavities of these teeth require the removal of at least a portion of the coronal plate. The extension of the carious action to the coronal surface of the tooth gives opportunity to effect reliable

retention of the filling without necessitating any more grooving or pitting of the proximate portion than is required to establish the first portion of the filling as a basis on which to construct the remainder.

The principles governing the formation and the mode of preparation of the two portions of the cavity are the same as has been described. When the walls are frail, they should be trimmed until sufficient strength of border is secured. Frequently, the proximate angle of the molars is much weakened by the extensive carious action, when it becomes necessary to cut it down with the object of restoring this portion, and in the restoration the weak walls may be completely protected from danger of subsequent fracture.

Proximate with Labial.—These are confined to the upper front teeth, and present many difficulties. The teeth so affected are usually of frail organization, much predisposed to caries and generally accompanied by active exciting causes of caries. Nevertheless, frequent good results are obtained. No plan of operation is admissible that does not contemplate the complete restoration of the lost structures, and no material for the purpose thus far employed is comparable to gold.

It fortunately generally occurs that the lingual plate of enamel is good, and as much of this should be permitted to remain as has any strength. The dependence for the support of the filling rests mainly upon this wall, and when it is so frail as to be of no service for this purpose the case generally requires the substitution of an artificial crown.

The retention is established by undercutting along the base of the lingual wall at the tuberosity of the tooth, by the cutting of two retaining-pits in the cervical wall, which may be joined by a groove cut between them, and by diverging inward the whole of the labial marginal line. The labial margin of the cavity should be smoothly and neatly formed, and should obviously not be extended any more than is required to secure a healthy border of enamel. The undercutting should be first made with suitable enamel-cutters, and finished by inverted cone-burrs in the engine. The former produces the clean line of the margin, and the latter the necessary even bevelling. It is almost needless to state that the burrs should be of the best quality in respect to form, fineness, and temper. The preparation is completed by the slight countersinking of the margin, which should be neatly done, either with a hard bit or a fine corundum point.

Proximate with Buccal.—The mode of preparation is similar to that of the last described division. The opportunities for retention are, fortunately, greater. The most important necessity of cases of this character is security. It should be kept in view that the movement of the inferior maxilla during the process of mastication is a combined lateral and backward one, and that it is accompanied by the application of great force. This force is communicated to the filling by whatever hard substance may be undergoing the process of comminution; and if the retention is not good extensive proximate fillings are liable to displacement. These dangers pertain with greater force to the division of cases now under consideration than to any others; therefore the greatest care should be devoted to the means of retention.

When the pulp has been devitalized, the pulp-chamber affords favor-

able opportunity of secure anchorage, and should be taken advantage of. When the pulp is alive and extreme sensibility exists, this must by all means be reduced. The retentive cutting is made by grooving the inner wall, by extending this groove somewhat over the coronal face, by forming at least two retaining-pits in the cervical wall, and by well undercutting the buccal margin. This latter margin should be curved rather than straight, and when opportunity exists should have a pit made in the dentine at its middle portion.

Proximate with Palatal.—When this combination occurs in the central incisors, unless there is an excessive loss of the inner plate it does not add to the difficulty beyond the increase of size of the cavity. The preparation is the same as previously described, where it is recommended to remove a portion of the inner plate to give better access. This combination is not an infrequent occurrence to the lateral incisors when it is caused by an enlarged sulcus of the inner plate meeting with a proximate cavity. When it does not involve the pulp, which is rare, the principal means of retention is made by undercutting somewhat the palatal cavity, and by whatever slight grooving may be made in the cervical wall.

When this combination occurs to the bicuspids, the general preparation is as usual. The retention is made by grooving the buccal wall, and by as large a pit as can be made at the base of the palatal portion of the cavity.

Where the inferior molars are involved, particularly when the lingual deficiency is near the neck of the tooth, the applicability of gold for the purpose is exceedingly questionable. Such cavities should be usually filled by a plastic material.

The Properties of Gold Foil, and its Manufacture.

Some consideration of the properties of gold foil and the means of producing it must be of considerable interest to those employing this agent, since a knowledge of the substances one is using as a basis of his daily effort essentially qualifies the results of his labors. Otherwise, it is like one planning to build without knowing the nature of the materials to be used in the construction.

The properties of gold which adapt it for the restoration of carious teeth are its softness, which enables it to be adapted to the form of the cavity; its tenacity, which permits facility of introduction and of consolidation; its resistance of chemical action, which prevents waste of the material by the various influences to which it is subjected; and its agreeableness of color, which when pure and unburnished approaches more nearly the shade of the teeth than does any other metallic substance. Its principal disqualification is its high conductivity of heat. There is no authentic evidence when gold was first used in dental surgery, but these properties must have suggested its use very early after some advancement in dental art had taken place. As being a more durable and sightly substance, it would naturally supersede lead, which was the first metal employed.

The result of its employment when the requirements of what consti-

tute a dental filling have been complied with may be regarded in the main as satisfactory, and it is often found to succeed well when all other materials have failed. Further, it is the concurrent testimony of the great majority of intelligent dentists of all periods that gold may be regarded as in all respects the most satisfactory material with which to fill carious cavities whenever the position of the case is not prohibitory and the quality of the tooth-structure is sufficiently dense to permit the required force to be employed without injury to the borders of the cavity. These elements qualifying success are, it is true, very variable ones, as a tooth which may be considered too soft to be packed with gold by the general methods of one operator may easily be done safely by another, whose methods are different, and in each case the degree of solidity aimed at may be the same. Or the method of one operator may include hand-pressure and the other may not have had efficient instruction in this manner of operating.

Every one using gold foil should so thoroughly acquaint himself with the properties of the metal as to know the good qualities or the deficiencies of each specimen, and be led to seek that which satisfies the requirements of the different classes of cases.

Purity of Gold an Important Property.—Purity of gold imparts to the foil the extreme softness it should possess and gives it the facility of being easily adapted to the surfaces of the cavity. However solid a filling of gold may appear to the eye and touch, if the gold composing it does not possess the property of plasticity, there is danger of imperfect adaptation at some point. The recognition of the necessity for this requirement of gold has not been general, and has not until recently been satisfied to any considerable degree. To indicate the superiority of the gold foil of to-day, it may be interesting to compare the present results with the analysis of thirty years since. A test made at the United States mint in 1854[1] of 1000 parts crystal gold gave $993\frac{1}{2}$ pure gold, in this respect declared to be equal to the foil in general use and superior to most.

However desirable, gold of absolute purity is rarely obtained, and from the great care and expense required its production is wellnigh impossible. The removal of the most infinitesimal portion of any of the other metals would be important if practicable, since any metallic combination with gold impairs its ductility and also causes it to harden more quickly by the application of instruments upon it than if it were absolutely pure. The slightest admixture of arsenic, antimony, tin, lead, etc. is sufficient seriously to impair the ductility of gold, a degree of these impurities amounting to much less than $\frac{1}{1000}$ having at one time embarrassed the operations of the English mint.

The impurities of crude gold as it is received from the mines consist principally of silver—which is always present—of iron, and of either iridium, platinum, or palladium. It may also contain lead, since a not inconsiderable portion of gold is recovered from silver which has been separated from galena. It may also be adulterated by arsenic and bismuth.

The usual process of purification of gold at the mints—which is the

[1] Dr. E. Townsend, in *Dental Recorder*, vol. vii. p. 173.

source from which the gold-foil manufacturers derive their gold—is by quartation. The silver is extracted by nitric acid, when the gold is left in the form of a dark powder. This yields gold from .995 to .998 pure. Sometimes the mints subject the amorphous precipitate to the action of boiling sulphuric acid after the completion of the first-named process. This nearly removes the trace of silver and raises the fineness to .998 or .999.

Gold, however, of even this degree of fineness is not sufficiently pure to produce the softest and the most tenacious foil, and therefore careful manufacturers are obliged to subject it to further processes. As the method of producing chemically pure gold from this highest result of the mints is too expensive and requires a high degree of skill, it only remains for the manufacturer to effect an approximation by the process of deflagration, which consists in continued fluxion of the gold with potassium nitrate, which oxidizes the baser metals, as zinc, lead, arsenic, and copper. It is further subjected to the action of sulphur dropped into the boiling metal, which combines with the remaining silver, and of corrosive sublimate for the removal of the last traces of iron. By these means the gold is rendered very nearly pure. A better method would be to subject the molten metal to a stream of chlorine gas under pressure, which is not practicable except in large operations. Foil made from gold so refined should be soft, extremely malleable, and of great tenacity.

As much of the gold foil produced is lacking in softness, pliability, and toughness, the indications are that it is made directly from the bullion furnished by the mints. These gold foils are harsh, unyielding after a few movements of the instruments, work unevenly, and when finished have a steel-like hardness which makes them unfit for the purpose of properly filling the usual cavities of decayed teeth. The great variation of the gold of the different manufacturers in the essential qualities of softness and tenacity indicates that many of them do not avail themselves of the necessary chemical means and make the foils of bullion, or else that their processes are carelessly performed.

The great divergence from the hardest foils furnished and Wolrab's gold, which is the softest known, is greater than is usually found in any line of manufacture where the standard is the same.

Making of Gold Foil.—The ingot of refined gold is rolled between steel rolls into very thin ribbons the thickness of tissue-paper. It is then weighed and divided into pieces of appropriate sizes to produce either of the Nos. 4, 5, 6, 10, and so on, some allowance being made for needed future trimming of the edges, the necessity for leaving the sheets of correct weight being kept in view. The little squares, to the number of two hundred, are taken up by wooden pliers and placed in alternate layers with sheets of vellum, which mass is called a cutch. A case of strong parchment is placed over the cutch in both directions, to enclose the whole in a secure manner. The mass is now beaten by means of short-handled hammers upon a block of marble resting on the end of a securely-placed block of wood, which should extend to the earth, to afford solidity of bearing. Considerable skill is required to attain evenness and to produce a good quality of foil, the physical properties

of gold being capable of alteration by the too great rapidity of the process.

The sense of touch determines by the heat evolved how rapidly to conduct the beating. Occasionally the sheets are exposed and shifted in the cutch. When the sheets are drawn out by the beating until they extend to the edges of the vellum, they are removed one by one into a larger cutch, and the process is completed. If they are too heavy to be reduced to the desired thinness, each piece is cut into four and the process repeated. The packet is repeatedly folded—or, rather, rolled—to prevent the gold adhering to the surface of the vellum and to keep the mass somewhat loose. When the proper thinness is attained, the sheets are taken out one by one with wooden pliers, and cut into size by means of a sharp reed on a leather cushion. The sheets are then accurately weighed, when they are ready for annealing.

This is an important and delicate process, and may be done in several ways, such as a frame of platinum-wire gauze with a spirit-lamp under it or in the muffler of a furnace. In whatever way it is done, it is important that the heat be high enough thoroughly to soften the gold and to do this evenly to every part of the sheet. The sheets are then put in the books so familiar to dentists.

From the first step to the last, the important features in gold-foil manufacture are that purity of all the chemicals be maintained, and that cleanliness be observed at every stage of the process. The care with which the goldbeater avoids handling the gold from the commencement of dividing the ribbon is a lesson to those bringing it into actual use that it should not be handled by the fingers nor exposed to deleterious influences of any kind.

There are certain distinct and easily-recognized properties of gold foil which have direct relation to its application to use for filling teeth; these are cohesiveness, non-cohesiveness, softness, hardness, tenacity, and fragility. These properties, on account of their importance, are entitled to separate consideration.

Cohesive Gold Foil.—When gold is refined by any of the ordinary methods in use—excepting, probably, precipitation by sulphate of iron—the foil made from it manifests a remarkable and peculiar property which causes one layer to adhere to another when they are laid together; and if these layers are brought into actual contact by pressure, they become inseparably united. On account of this union being a real and permanent one, gold having this property is called cohesive. Previous to the recognition that this power of union is the same as that which holds the particles of the mass of metal in union such gold was called adhesive, in agreement with the appearances presented. This property is independent of the absolute purity of the metal; it may contain a notable quantity of any of the deoxidizable metals and still possess it. Silver, it is believed, increases the cohesiveness of gold, but lessens its softness.

The property of cohesiveness of gold is one of the utmost importance to dentists. Its existence was not recognized until a recent date, but it appears from all the facts obtainable to be the natural condition of all gold in a state approaching purity when prepared by the ordinary pro-

cesses. This is supported by the testimony of all workers of gold, and is confirmed by the fact that the crystals of gold produced by electrolysis, as soon as they are washed and dried, are capable of being brought into inseparable union on the application of slight compression, the law apparently being that the metals, when brought into actual contact, become amenable to cohesive force. Of this there is familiar proof in the union of two disks of tin or lead having freshly-prepared surfaces, of spongy platinum after being heated sufficiently to drive off the occluded hydrogen, and of the occasional union of disks of iron under the weight of heavy vertical mill-shafts.

This property is manifested by gold foil only directly after it is finished by the annealing process, but is capable of being restored by heating it to near redness. Exposure to the atmosphere constantly overcomes the property, which may be renewed at any time by heat. The duration of this condition is comparatively short, deterioration in this respect being apparent in an hour after annealing and being entirely lost by the interval of a day.

There are two hypotheses given to account for this phenomenon of the loss and restoration of cohesion, one being that atmospheric and accidental gases become occluded with the gold in a state of coldness, which prevents the layers of gold from coming into contact, and therefore makes impossible the welding of the metal, and that when by heat these gases are driven off the gold may be brought into union simply because no adventitious substance intervenes. The other hypothesis is that heat induces certain molecular changes in the gold which develop the property of cohesiveness. There is an assemblage of facts to support both hypotheses, and the conclusion may be reached that both postulates are true and that they are inseparably connected in the phenomena presented.

When it is desired to cover a given metal with another in such a manner that the deposited metal may adhere, it is necessary to cleanse the surface, dip it in nitric acid, or heat it, when the new metal becomes fixed. But if it is desired to separate the deposited metal, as in copying coins or medals, the original must be exposed to the atmosphere for at least twenty-four hours, the deposited metal then being separable. The explanation of this fact is that in the latter case the original medal becomes coated with a dense film of gas. These and other well-known facts appear to indicate that gold holds no exception to the law of metallic occlusion of the gases. It has not, however, been determined for what gases it has the greatest affinity or in what volume the occluded gas is held.

This property of the metals was first demonstrated by Graham and has been confirmed by other chemists, who give striking instances, in some of which the gases are so much condensed as to be in nearly a solid state.[1]

If a roll of several sheets of pure gold be folded into a loose rope, annealed, and suspended in sulphuretted hydrogen, and afterward immersed in ammoniacal gas, it will be observed, if the roll of gold is then heated, a sublimate which proves to be sulphuret of ammonia

[1] Regnaut's *Chemistry;* Gray's *Chemistry.*

may be collected upon a cold porcelain slab held directly over it.[1] In a similar manner, a sublimate of chloride of ammonium may be produced by substituting chlorine gas.[2] If this roll of gold, before being submitted to sulphuretted hydrogen and chlorine, manifests cohesiveness, this property disappears after the exposure, and it is not then capable of being welded. The same result occurs if the gold be suspended in any of the ordinary gases, as ammoniacal, hydrogen, carburetted hydrogen, phosphoretted hydrogen, sulphurous-acid gas, etc.[3]

These facts conclusively prove that the gases either produce some physical impression on the gold or interpose themselves as an obstacle to contact of the layers.

When gold foil kept for some days somewhat exposed to the air is heated, it gives out a distinct odor similar to ozone, and sometimes the lamp used for annealing has the color of its flame changed.

When gold treated in the manner above indicated is heated, the gases are dissipated, and the gold has its property of cohesiveness restored, except when acted on by two groups—those formed from sulphur and phosphorus.[4] Any gas into which either of these elements enters becomes so attached to the gold that it cannot be removed by annealing; great precautions are therefore required to protect gold foil from contamination by these gases, which are very prevalent ones, particularly the sulphur group. Careful and close wrapping alone is not sufficient, as, notwithstanding this means of exclusion, gold is frequently injured. The presence of the usual fires when the combustion of fuel is imperfect, together with the decomposition of organic substances, is sufficient to keep the air charged with enough sulphuretted hydrogen at length to impair the foil. The lighting of matches about the instrument-case may also supply sufficient phosphor-compounds to effect the same deleterious influence.

Dr. Black, from whose paper many of these facts have been collated, has made the important announcement that ammoniacal gas has the power to prevent the injurious influence of the deleterious gases, either by its protective presence, or more probably by combining with them to form harmless salts. He recommends keeping in the gold-drawer a bottle of carbonate of ammonia, which he found completely to protect his gold from the contaminating influences of an adjacent chemical laboratory. The power of ammonia in this direction has been favorably tested by others. Black also makes a further statement of importance—that gold treated in this way is made non-cohesive and may be worked as such.[5]

If a sheet of cohesive gold be heated and placed in the receiver of an air-pump and the air be exhausted, it is found that after a period of twenty-four hours the gold has lost its cohesiveness the same as though it had been exposed to atmospheric influences; if, at the same time, a piece of cohesive gold which has lost its cohesion by atmospheric exposure be placed in the same receiver, no influence is effected upon it.

[1] Black, *Dental Cosmos*, vol. xvii. p. 139.
[2] *Ibid.*
[3] *Ibid.*, p. 140.
[4] *Ibid.*, p. 141.
[5] Those wishing to follow Dr. Black's investigations will find them in the Missouri *Dental Journal* for July, 1869, and *Dental Cosmos*, vol. xvii.

These coupled facts would appear to confute the first hypothesis, and would be conclusive if the vacuum were absolute, which is never the case. It may yet be proven that the affinity of the metals for the gases is sufficient to condense them notwithstanding the rarefaction of the vacuum. But certain well-known facts having some bearing on this subject should not be overlooked. If gold foil be moderately heated, it becomes cohesive to a degree which permits a nearly inseparable union to take place; but if it be heated to a white heat, this property becomes excited to an excessive extent. The soft cohesive foils, when used without annealing by the Herbst process, become cohesive under the heat generated by the rotating instruments. When a cavity is packed with unheated gold by means of deeply-serrated instruments, considerable cohesion appears to be developed by the heat of friction occasioned by the penetration of the long points. This appears only at the part where this excitation takes place.

This interesting subject requires further careful investigation. Notwithstanding that the evidence is conclusive that without the removal of occluded gases the layers of gold cannot be brought into contact, yet in the present state of our knowledge the conclusion is entirely reasonable that cohesion depends *per se* upon the excitement of heat, which must be at the same time sufficient to dissipate the gases. It will be observed that other facts connected with the heating of non-cohesive gold further complicate this subject.

The existence of cohesiveness as an inherent property of gold remained unrecognized until the experiments of Dr. Arthur revealed it. Whatever observations had been previously made were of an indefinite character, being simply a recognition of the fact that the gold of certain makes was more cohesive and made more solid fillings; but in this there was no cognizance of the existence of so important a property as we now daily make intelligent use of. There was no literature upon the subject or allusion to it in the current journals until the accidental discovery made in 1855 by Dr. Arthur, who immediately saw the value of this property and devised the means to regulate and to make intelligent use of it. The result is illustrated in his book on the subject.[1] The greater testimony, however, to Dr. Arthur's keen appreciation of what this property would accomplish is evidenced in the revolution it has made in dental surgery, and in the possibilities it opened out in the direction of substitution of lost tissue and restoration of form.

While cohesive gold has increased the field of dentistry and when intelligently employed is of incalculable benefit, it has also done immeasurable harm by being used when it was not applicable and by means which failed to produce that most requisite result, adaptation to the marginal walls. The endeavor will be made later on to indicate the manner in which to use this description of foil to secure its benefits and to avoid the dangers which lie in its improper employment. On account of the great defectiveness of much of the cohesive gold now in use, and more particularly of that generally supplied some years since, an erroneous impression has arisen that such gold is necessarily intractable and that it is in its nature harder than other kinds of gold, and for this

[1] Arthur, *Adhesive Gold Foil* (1857).

reason it has been named hard gold. The only warrant for this, when it is pure, and thus soft, is that, as it is capable of being condensed into a condition of absolute solidity, it in this state appears less yielding. The fact, however, is, as previously stated, that the most cohesive gold is, if pure,extremely soft and yields in lateral directions on the application of force. Should, however, an admixture of such metals as copper, platinum, palladium, zinc, etc. occur, even to the smallest amount, the gold, while losing none of its cohesiveness, is perceptibly hardened, and it then becomes absolutely intractable. Such gold is truly hard, and it is unfit for filling teeth except for the special purposes of surfacing fillings exposed to the direct action of mastication, when it is demanded that the gold shall receive the full shock either of the teeth or of other similar masses of gold.

Soft cohesive foil is usually of very light color, and when shaken the tone of its vibrations is comparatively low. When worked, after annealing, by means of the mallet, the sound of the point upon it should be dull, and it should give under the instrument. On the contrary, the hard cohesive foils when shaken give out a comparatively high tone; and when annealed and worked by the mallet, the sound of the blow is more ringing and the gold does not readily yield before the instrument: it is disposed to ball, has a tendency to unevenness of the surface, and, as before stated, is intractable to the burnisher. In working it by the hand-mallet the first blow, which is intended to overcome the irregularities of the surface and bring about adaptation, induces the immediate development of intractability, which makes necessary undue malleting to produce consolidation.

Non-cohesive Gold Foil.—This should be described as a pure gold which is incapable of cohesion even after being highly heated. In this respect it must be distinguished from cohesive gold, which by exposure apparently loses its characteristic property. This distinction is one having important differences, and confers on non-cohesive gold properties which adapt it to purposes for which the latter is unsuitable. The failure properly to comprehend these differences has led to numerous mistakes and produced many unfortunate stoppings. It is a too common error to designate gold of this character as soft gold, in contradistinction to cohesive gold, when the fact is that both kinds may be physically soft or physically hard according to the degree of the impurity and the nature of the metals constituting the admixture previously shown in this section.

The terms soft and hard in their improper use came to be applied at a period when the purification of gold was less practised than at present, and terms indicative of apparent qualities were accepted instead of those expressing real properties. The time has arrived when correct distinctions may well be established and easily understood.

The varying degrees of the property of cohesiveness of the gold of different makes, the fluctuating period of retention of this property after its excitation, and the related fact that some grades of gold of pure refinement are not at all cohesive and are incapable of being rendered so, would indicate that some other physical property than those alluded to above may be impressed upon gold foil. It has been assumed

that, as gold as ordinarily prepared is cohesive, non-cohesive gold must, therefore, in some manner be alloyed to impair this property. This does not seem to be necessarily the case, since none of the metallic elements have this power, excepting, possibly, iron, which will not sensibly harden the gold.

As early as 1857, Mr. Morgan prepared for Dr. Arthur three grades of foil from the same refining, one being so excessively cohesive as to unite on the least touch, a second requiring some force to produce union, and a third absolutely without the property of cohesiveness.[1] Mr. Morgan gave the assurance that each of these grades of gold was of equal purity, but, unfortunately for the purposes of investigation, he was silent concerning the means by which these varying properties were effected. That a physical impression may be made upon the gold without impairing its purity is demonstrated by the conditions produced in what is called carbonized gold. This is made by roasting cohesive foil in contact with an intervening sheet of paper until incineration of the paper takes place. The gold is thereby rendered non-cohesive, and an amount of heat which would drive away any organic matter will not restore the cohesion. Other substances may have the same power as the gaseous products of the incineration of cellulose.

While non-cohesive gold, even when short of absolute purity, is more yielding when used in mass than the purest cohesive, it is important that it also be as nearly pure as possible; for then, on account of its leadlike softness and its greater tenacity, its working qualities are, relatively, very remarkable. In this condition it retains its softness under the instruments to the last moment and is capable of adaptation to the margins of cavities by the application of slight force.

The uses of this kind of gold are for filling the larger part of accessible cavities of the first division, for the commencement of proximate cavities, and for the purpose of lining the labial walls of the front teeth and all weak borders.

The means of testing whether gold is non-cohesive is to heat it to redness in an alcohol-flame; if it then manifests the least cohesiveness or loses its leadlike softness, it should be laid aside for other uses as an intermediate gold. If, after heating, the tone of its vibratory sounds becomes sharper, or if its color is somewhat red, it contains some impurity, and is therefore lacking in softness.

Non-cohesive gold, when perfectly pure, is nearly as soft as tin, is more manageable, and differs but little in its working qualities from the latter metal, except in the particular that the property of gold to become tempered when subjected to friction is greater than the same property of tin.

Preparation for Use of Different Kinds of Gold.

A generation since, there were but three forms in which gold foil was employed—viz. the pellet, the rope, and the tape. The most common form was the rope. At the present time the various forms used are numerous, and no one, as then, is confined to any given one. The

[1] *Adhesive Gold Foil*, Robert Arthur, p. 27.

pellet and the rope have become nearly obsolete, and have given place to the tape, the mat, the compact and loose block, the compact and loose cylinder, the ribbon, rolled gold of considerable thickness, gold plated with platinum, and crystal gold.

The tape is made by folding any portion of a sheet over and over again until a desired width and thickness is produced. It is not, however, considered advantageous to have the number of folds in each tape greater than eight, which, when the gold is No. 4, makes the tape equal to No. 32. If the tape is to be used in this form by folding it into the cavity, as will be described later, it should be of non-cohesive gold, since otherwise the adherence of the folds as they pass and touch each other becomes an impediment to consolidation. The tape is most conveniently formed by laying the suitable portion of the sheet upon a clean napkin or a piece of amadou, and, after placing the edge of the gold spatula in the middle, the napkin and spatula are laid over to one side; this is done three times successively. By this means the gold is formed into a tape without the fingers having come in contact with it, which is a point of considerable importance, since the cleanest fingers will impart some soil to the foil.

The Mat.—If it is desirable, for any reason, to use small portions of the tape, it is cut transversely in small pieces, which are called mats. These, when of non-cohesive gold, are of considerable use in very small cavities, and are also of service in large fillings when made of semi-cohesive gold. One form of tape is made by a tool which compresses the gold into this shape; if from this kind of tape mats are cut, they may be used with advantage if of very cohesive gold. The mat is of most service in proximate cases when there may not be sufficient room to introduce larger and thicker pieces of gold. These can be inserted edgewise between the teeth, and afterward be carried into place and consolidated according to the method of packing employed at the time. The mats of non-cohesive gold are frequently of service in filling the smaller sulci, particularly of the bicuspids.

In introducing cohesive-gold mats the best results are produced by making thin layers of gold, since the force employed is more effective in producing thorough consolidation. If thick masses like pellets are employed, much of the force is distributed in overcoming the impediment presented by the corrugations.

The Block.—The compact block is formed by folding a tape on itself a number of times, which is done by seizing it in the pliers and making turns of any desired size, either square or narrow. This form should be composed of non-cohesive gold, as otherwise a mass of so compact a nature would become unmanageable by the cohesion of the layers.

These blocks are useful in commencing large proximate cavities, they being used upon the cervical wall. Their form, the parallel directions of their layers, the plastic nature of the arrangement of the layers, and the softness of the gold comprising them, enable this part of the filling to be easily started. They are also excellently adapted to simple crown-cavities where it is not difficult to effect their placement. This form of block has sometimes been erroneously styled a cylinder.

The Loose Block is composed of cohesive gold, and is generally made

of what is called corrugated gold, the purpose of the employment of the latter being to prevent the layers from touching at more than a few points. This form of block is made by laying sheet upon sheet until a number of layers are so placed, when the mass is cut into squares with a razor-like instrument.

These blocks are useful only in building up gold upon a previously-established foundation of cohesive gold.

The Compact Cylinder.—This form is made by rolling a tape of non-cohesive gold upon a fine broach, commencing at one end of the tape and continuing the movement until the desired size is reached, by which means the cylinders may be made very compact.

Cylinders are employed in filling cavities on buccal and coronal surfaces. Dr. Clark, the inventor and introducer of the compact cylinder, recommended them for filling all forms of cavities, but the method has now fallen into disuse except as indicated.

The Loose Cylinder bears some external resemblance to the previous kind, but is in all other respects very different. Cylinders of this form can be made only by the manufacturers. They are composed of several sheets laid one upon the other, and are then wrapped loosely upon a needle-like piece of steel. When the broach is removed, they are cut into definite lengths by a sharp tool, and are distributed in assorted sizes. They are usually made of corrugated cohesive or semi-cohesive gold, and they complement the loose block. They are employed in the commencement of fillings, for which purpose they are not usually annealed, and are recommended on account of the facility with which they can be packed. There is, however, considerable loss of force in overcoming the corrugations of the foil of which they are composed. Still, there is no question that there are certain advantages possessed by these cylinders, as, when they are fixed at one end, there is less danger of displacing this fixed portion when force is applied to the other end, for the reason that the corrugations permit some movement to take place in the unconsolidated part without disturbing the part first secured. Probably on account of the impediment offered by the corrugations, they are not well adapted to building out in contour operations, and other forms should be substituted when this portion of the operation is reached.

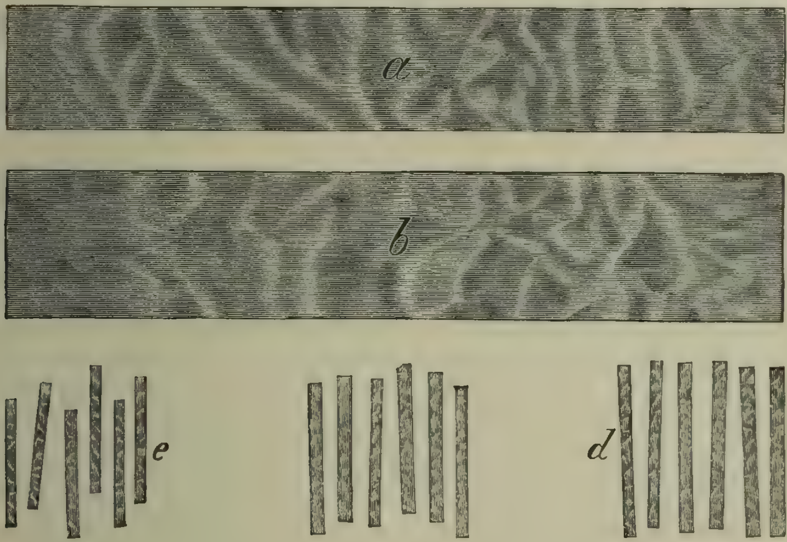
The Ribbon is formed of whole sheets, and, in some cases, of two sheets, of flat cohesive foil folded like a tape three times, which produces No. 32 when one sheet is taken. The folding should be loosely done. These ribbons are shown at Fig. 80. The ribbons are taken up with delicate foil-pliers and cut across into little strips, represented at *d* and *e*, care being taken to protect them from injury, the width of these strips being varied with the size of the case. Each of the strips is afterward taken up by pliers and heated to redness at the moment of using. It was with this form of gold that the beautifully executed operations of Dr. Webb were generally performed.

This form of gold is properly adapted only for building out teeth beyond the confines of the cavity and for entirely filling such cases as depend for their support and retention upon a few retaining-points or imperfect grooves which have been formed in weak margins. It is also the form of gold best adapted to the use of the electro-magnetic mallet,

for the reason that, as that instrument is efficient only through insensible distances, it is important not to have much bulk of gold beneath its points.

Rolled Gold.—Several thicknesses of heavy gold have been recommended, in some instances as high as No. 160 having been used. Reasonable practice in this respect has settled that Nos. 20 to 30 are the proper limits of heavy foil.

Fig. 80.



Pure gold prepared by rolling has a remarkable degree of softness and toughness, and when made cohesive manifests this quality in a higher degree than the same gold would if beaten into foil. When made of cohesive gold and this property fully developed by heat, the adhesion is exceedingly tenacious, which adapts the gold to building out cases and for surfacing fillings when it is important to produce a homogeneous appearance of the surface. When made of non-cohesive gold, narrow strips may be inserted along the margins of stoppings packed by hand-pressure, and they may also be used for filling the pulp-canals. In this form it is not difficult to pack it into fine roots, and in this situation it will also well bear malleting.

Gold Plated with Platinum.—This form of gold was introduced for the purpose of filling surfaces of the teeth exposed to view. To produce it, a bar of pure gold is soldered upon a bar of platinum, when the two are rolled down to any desired thickness and used as heavy gold. The commingling of the color of platinum with the gold imparts a tint more nearly the shade of many teeth than is the color of gold. Another use of gold prepared in this manner is for the surfacing of teeth which have been reinforced to compensate for loss of substance on their points or on masticating surfaces.

The greater hardness of the platinum and the hardness produced at

the line of fusion by the partial admixture of metals render this form of gold sufficiently enduring to withstand the shocks and friction to which fillings in these positions are subjected.

This kind of gold is not adapted to compose the body of fillings, since to produce solidity more force with the mallet is required than is safe for other than teeth of excellent quality.

Crystal Gold.—This was first introduced in available form by A. J. Watts about thirty years since. At first, and for several years, the material was imperfectly prepared, being in some instances a simple precipitate of gold, usually by oxalic acid, and was of uncertain and unreliable quality. Watts's early preparations were made by treating the precipitate by nitric acid, the acid being neutralized by ammonia; the gold was then found in a crystalline condition. These crystals were as thoroughly washed as was possible with so spongy a material. Afterward it was thoroughly heated on a slide in a muffle, when it was ready to be used.

This gold came into wide use for a time on account of the ease by which apparently good fillings were made, but because of occasional contaminations of the gold by the incomplete removal of the nitric acid, and also owing to the hurried and careless manner of introducing and packing, it fell into great discredit, and so remained until the manufacture of crystal gold by electrolysis was effected; since this period it has had moderate employment. It is now an entirely unobjectionable preparation, and with it most perfect fillings can be formed, the material, as now produced, having the most beautiful arrangement of crystals in laminate form, which possess excessive cohesiveness and considerable plasticity.

Certain precautions are required for the use of this seductive, and even now somewhat deceptive, material, which will be given in the proper place. For the general body of a filling it does not possess any advantages over foil except the facility afforded of the fixation of the first pieces. Properly to use it requires more care than to produce results equally as good as with other forms of gold, which is evidenced by the fact that its employment is comparatively limited. Owing to the fact that the forms of the crystals of gold are cuboidal and somewhat less soft than other pure gold, its use in contact with enamel margins is contraindicated unless the teeth are very hard. The crystals, however minute, have to be somewhat flattened out at the point of contact with the margin; and if it be conceded that the solidity of the ultimate surface against the margin is made secure by the driving forward of smaller crystals to fill up the minute interstices between the larger crystals, the indication remains that the movement of the crystals is impeded by their cohesion, which abridges their consolidation. On inspection the interior surfaces of fillings made of this kind of gold, even when well done, are not found to present the smooth appearance that well-performed fillings of foil usually have. The indications are that the material is better employed after a thin lining of foil of some form suitable to the case is made on the principal walls.

Great care must be exercised in using crystal gold that it be not condensed in the preliminary manipulations, that it be preserved from all impurities of gases and from handling, that the pieces used be not

too large, that they be disposed in a thin layer over the surface of the filling as it advances, and that this layer, after being slightly compressed, be thoroughly condensed by rather small instruments before another layer be made. With these precautions, most excellent results are reached.

Some of the most remarkable operations of thirty years ago were performed with this material, imperfect as it then was—notably, those executed by Dr. Dwinelle.[1] These operations were considered marvellous, but, as before stated, the imperfections of the material and hurried operations performed by those who were attracted by these results gave the use of this material a shock from which it has not yet recovered.

Annealing Gold.

The process of annealing gold as the finishing step in its manufacture has been alluded to. It is then done for the purpose of reducing the hardness caused by the mechanical forces to which it has been subjected.

After foil has been kept for a short time it loses some of the qualities it possesses when freshly made, but these may again be restored by the application of heat, in case it has not been exposed to the deleterious influences of several of the gases, as previously shown. Cohesive foil in a few hours loses nearly all of this property, and non-cohesive foil, after being kept a fortnight, unless it be maintained under pressure, loses some of its toughness; but this latter species of foil, as has been demonstrated, unless it be truly non-cohesive, will on being annealed become adhesive and is liable not to fulfil the requirements demanded. It cannot then be manipulated in the manner to be described.

All gold, after being kept for some time subjected to shocks and movements of the packages, loses some of its softness, and needs annealing to restore this quality. The property of the adhesiveness of reannealed foil was discovered by Dr. Arthur, through having annealed, to recover its softness, an old book of long-kept foil which had lain in the case for months.

There does not appear to be any particular method required for annealing foil, notwithstanding the various directions which have been given, it being only necessary to heat it in a flame which does not contain either sulphur, chlorine, or phosphorus. If cohesive gold be heated in this manner, its distinctive property is fully restored; and if, when it becomes necessary, the same is done to non-cohesive foil, its original toughness and its ability to be packed with great density return without making it harsh. In case it is desired partially to develop the property of cohesiveness, the foil is heated on a plate of mica, platinum, or iron, which is held over a flame of alcohol or gas.

In practice, to produce the best results in annealing mats of cut ribbon, the pieces should be cut from the unannealed portion of gold and then passed through the flame of alcohol at the time of using it. Strips of heavy gold such as No. 20 are better annealed in the strip previous to cutting off the pieces. The loose cylinders and blocks of the manu-

[1] For which see an exhaustive and admirably-written monograph by Dr. Dwinelle in the *American Journal of Dental Science*, vol. v., New Series, 1855, pp. 249–297.

facturers are best heated on a plate over either an alcohol flame or a Bunsen burner.

It should be observed that in working cohesively on important surfaces the pieces of gold, if handled in annealing by the pliers, are but little heated at the point touched by this implement, and should therefore, to produce the best results, be annealed on a hot plate of metal. All non-cohesive foil is better heated in the same manner over an alcohol flame, since it is necessary only to drive off the film of adherent gases to permit the layers to come into close contact, but without union.

These methods of heating are important means of testing the properties of different specimens of gold, and the careful operator will make these tests in order to enable him to select for different purposes his supplies of this material.

Tin Foil.

The properties of tin which adapt it for the purpose of forming stoppings are its softness, tenacity, low conductivity of heat, and its indisposition to harden during mechanical manipulation. Its disqualifying properties are its color, its liability to undergo some oxidation in the mouth, and its too great softness when placed in situations exposed to much friction.

It is essential that the metal be in a state of chemical purity, which, fortunately, is a result not difficult to secure. The form in which it is generally used is in sheets of foil of various thickness. The foils made at the present time are of great superiority in every respect in comparison with those of a few years since. They are prepared for use by being formed into tapes, blocks, or mats, according to the exigences of the cases, and are used in the same manner and by similar instruments as for non-cohesive gold.

An excellent plan is to fill the cavity nearly to fulness and then incorporate rolled tin of a thickness equal to No. 60, or even heavier, using for the purpose single-line points.

To secure good results from the use of tin, it is necessary to pack it to a state of considerable density. To do this, however, requires great dexterity, as, on account of the entire absence of cohesion and the extreme softness, the pieces of foil do not keep their place as well as gold does. On account of this tendency and of its great softness, it is allowable to use, in starting, quite large blocks of the foil, wedging them together until a secure foundation is effected, when the remainder may generally be added without difficulty. This foil does not well bear malleting excepting for the purpose of effecting surface consolidation, when the instruments should have broad faces. When, however, it is employed in conjunction with a matrix, there is no objection to the mallet, since the blocks cannot escape from the cavity, and are therefore driven into form and perfect adaptation to the walls.

As tin fillings are capable of easy condensation after the material is packed, it is of great advantage to overfill the cavity during the packing process. Very considerable condensation can then be effected by broad instruments, and also by well-adapted burnishers. The finishing

of the fillings is easily and quickly done by means of trimming-knives, burnishers, and pumice-stone.

The purposes of tin fillings are quite varied, and their advantages are so very great under circumstances unfavorable to gold and some other materials that it is remarkable they are not more generally used. The various uses are for children's teeth of somewhat inferior character previous to full calcification, for the back teeth of all persons when similar conditions exist, for deep-seated cavities when the pulp may be nearly exposed, as a temporary filling in highly-sensitive teeth when for any reason therapeutic treatment is not admissible, for the treatment of the deciduous teeth of children—where, all things considered, it is an admirable material—and for the filling of root-canals. Attention will be carefully directed in the proper place to its use for temporary fillings in cases of exposed pulps, where, on account of the slight conduction of heat, recuperation is stimulated, and, on the other hand, the low conductivity is favorable to the avoidance of thermal irritation.

A form of tin called Robinson's metal, which is prepared in a fibrous state and said to contain some platinum, with which it is easily alloyed, was introduced some years since. The presence of the platinum gives to the admixture greater hardness than pure tin, and the spongy character of the material renders it more easily manipulated. There also appears to be some cohesiveness between the layers as they are introduced. This material, however, requires considerable caution in its use, since, as it possesses some of the same physical characteristics as crystal gold, it is necessary to introduce it in thin layers to secure a proper degree of solidity and the certainty of adaptation to the margins. It requires, also, to be kept scrupulously dry. These disqualifying conditions limit its use in comparison with tin foil, however much it may possess the superior quality of an enduring surface. But in this latter respect it may be used with advantage as a means of surfacing fillings of tin foil.

General Principles Concerning Packing of Gold.

The general characteristics of both cohesive and non-cohesive gold having been considered, and the forms in which they are prepared for use having been described, it comes naturally in order to discuss the application of gold to the filling of the prepared cavity.

When the cavity is filled with pieces of gold, the mass is retained by the mechanical form of the cavity, as has been previously shown; but, unless the pieces of gold are placed in correct relation each to the other and to the walls of the cavity, or are perfectly united together, the mass may become disintegrated, and some portion at least may escape from the cavity and disfigure the filling or lead to the ultimate injury of the tooth. There are three methods by which the gold is packed to obviate this accident—viz.:

1. By mechanical arrangement of the layers of gold;
2. By incorporation of the layers of gold;
3. By cohesion of the layers or particles of gold.

The first is applicable to non-cohesive gold; the second, to the com-

bination of cohesive gold with non-cohesive; and the third pertains exclusively to cohesive gold.

Mechanical arrangement of the gold has reference to the manner in which blocks, tapes, cylinders, and mats of the material are disposed in the cavity when the layers or folds extend from the bottom of the cavity to the surface, or nearly so far, and are so arranged, forced, and wedged together that no one of the pieces can easily escape.

By incorporation of the layers of gold is meant the working into a mass of mechanically-arranged gold strips of heavy gold such as Nos. 20, 30, 40. This is done by means of wedge-shaped, sharp single-line points, which are used to force the cohesive gold between the layers of the non-cohesive gold at a moment before its full condensation is effected. If proper force is used, the whole face of a mass of non-cohesive gold may in this manner be given a surface of cohesive gold which is inseparable from the lower portion, and which may be made the basis for continuing the addition of any amount of cohesive gold. This is an important method of introducing gold, as it enables large fillings to be inserted in less time, and in some instances with greater safety to the teeth. It also allows the cervical portion of many proximate fillings to be made of non-cohesive foil and completed by cohesive gold at a part which may require building out to restore the form.

This method is also of great service in the filling of front teeth on their labial surfaces, as the margins may be protected by non-cohesive, and the whole central portion may then be filled with cohesive gold, which may be extended nearly to the ultimate margins.

It should again be observed that in packing by this method the incorporation should be commenced before the surface of the non-cohesive gold is condensed, as condensation would prevent the cohesive strips from being introduced to sufficient depth. The process of incorporation, the form of the points used, and the mode of applying the force, effect the desired condensation. The hesitation of some to combine gold by this plan may be caused by disregard of these considerations.

The third method of packing gold consists in simply taking advantage of the cohesive property of gold, and is effected by establishing a starting-point in a retaining-pit at some strong portion of the cavity, fixing in this some gold, and gradually adding piece by piece until the mass fills the cavity at all parts and at length slightly extends over the borders, beyond the line of the countersinking. The packing may then be continued at such portions as may require building out to the form which fulfils the subjective plan of the stopping.

Considerable force is frequently required to bring the folds of gold into exact contact with the mass previously fixed and with the walls of the cavity. Gold being a soft metal, and the sheets being thin, it would not at first thought appear to need much force to effect these objects, but in practice it is found that it is otherwise. This is because several impediments are offered to the adaptation of the material—viz.:

1. The natural rigidity of the material;

2. The friction of the layers as they move one upon another against the sides of the cavity and against the irregular surface of the previously-packed gold;

3. The air contained between the layers and occluded within the folds of the gold;

4. The simple corrugation of the gold and its crimpling.

These impediments, excepting the last one, are so obvious as to require no explanation. Of corrugation it should be said that it probably causes the most considerable resistance to the force, since as the gold approaches a state of density this relation of the minute parts of the surfaces becomes more abrupt. Crimpling may be described as the tendency which the material, of whatever form or kind in use, has to curl backward toward the instrument. This tendency is, for instance, marked where direct pressure is made upon a block of gold. It is observed that the free portion of the gold draws away from the surface upon which it has been laid. This inclination is, however, a general one, and requires constant effort to overcome it.

These various resistances have to be overcome by force, which is applied by several modes—viz. 1. Direct pressure; 2. Wedging; 3. Leverage; 4. Percussion.

Direct pressure in packing gold is usually simply a preliminary movement to place the gold in position, and becomes the basis of the further means of overcoming the various resistances described. Direct and simple forward movement of the instrument, unless accompanied by an amount of force which would frequently be injurious, is of little avail; but when followed by either of the other before-mentioned forces, solidity may be secured without apparent effort and without injury.

Wedging is essentially effected by the form of the point of the instrument, which on being inserted between the layers of the gold forces these sidewise and drives the layers contiguous to the instrument into closer contact. This means is of great efficiency in packing gold in small cavities of all kinds, whether of direct or indirect approach, and is more particularly applicable to the employment of mats of gold and when the gold is worked by incorporation. In this manner, also, strips of the heavier kinds of gold, as Nos. 20, 30, 40, may be packed together or incorporated with previously-packed portions of gold blocks.

Leverage is, however, a much more efficient and powerful mode of applying force. It may be used in packing all forms of gold, whether cohesive or non-cohesive, and some explanation of this manner of applying this force will presently be given.

When, for instance, several blocks of gold are inserted loosely in a simple and strong cavity, if a wedge-shaped instrument be inserted between the layers, it will enter until the impediments arrest the movement. At this moment, while pressure is continued, if the instrument be tilted in one direction, the opening is enlarged; and if it is quickly moved in two or more directions, the opening is greatly increased.

Also, when one or more blocks of foil are placed at one side of a cavity, the point of the instrument which inserts them is applied with some direct pressure toward this wall and is then tilted edgewise, which condenses the bottom portion; the next succeeding sidewise movement, while using the point as a fulcrum, forces the folds of gold against the wall.

When gold is packed by incorporation, the instruments being wedge-shaped, if leverage be used, the gold is forced into the previously-packed portion with facility and into a condition of great solidity.

It is obvious that in packing gold by leverage the general movement of the instrument should be in the direction toward the point at which the gold should be placed. Thus it should be toward the ends of sulci, the margins of ordinary coronal cavities, and the cervical wall of proximate cavities, to overcome more particularly that form of impediment called crimpling. This illustration is more particularly to be enforced in reference to the cervical margins of proximate cavities.

In the use of powers so forcible as the wedge and the lever due regard must constantly be had to the degree of strength of the walls of the cavity; the force must be graded accordingly, and the mass of gold under the instrument must also be proportioned to the same conditions.

Percussion as a means of overcoming the aforesaid resistances is probably more efficient than leverage, but is more particularly applicable to the packing of cohesive gold, and is better adapted to overcoming the irregularities of the surfaces of the gold than any other mode of applying force. The use of percussion is of considerable importance in the wedging process; and when gold is packed by incorporation, the blows of the instrument drive the wedge-shaped points to greater depth. In some cases, also, where the direction may be too indirect for leverage, percussion may supply the requisite force.

The three principal physical qualities of a metallic stopping are, in the order of their importance, 1. Adaptation of the material to the walls of the cavity; 2. The form of the external surface; 3. The density of the mass.

These conditions, in their subordination, have relation to the purpose of the filling which is to secure the highest conservation and best use of the organ. As the chief purpose of a dental stopping is to exclude every foreign material and fluid from having access to the interior of the cavity, it is too obvious to require explanation that the first quality is of the greatest concern; for without this, whatever the form, and however great the density, the stopping is quickly useless. It is necessary for the highest purposes of the filling not only that the adaptation be complete at the margins, but that it be so throughout the whole interior of the cavity. This is required not only to maintain the homogeneous appearance of the enamel when the filling is of the front teeth, but to prevent any subsequent attack of caries from quickly penetrating beneath the gold and insidiously causing destructive changes at the deeper parts of the cavity. If the adaptation be complete, the injury by the recurrence of caries may be limited to the point of its occurrence, and may then be repaired without difficulty.

The form of the filling is of next importance, because upon this frequently depends the protection of the margins from the recurrence of a carious attack, and upon it rests the question of the usefulness of the tooth of which it becomes a component part. Whilst the teeth in some of their variations of form are physiognomically characteristic of the individual and may have expressions stamped upon them of family,

nation, and race, they are in their most essential elements of form adapted to the performance of function. This guiding principle should therefore govern the shape which is to be given the surface of the filling. To see this clearly in the light of its own illustration, the form of the coronal surface of the teeth is composed of elevations, with corresponding depressions of the opposing teeth. These depressions are also found to be deeper than the related prominences; this is not only for the purpose of enabling finer comminution of the food, but to grasp and detain it between these opposing surfaces. The outer faces of the teeth are rounded and decline inward toward the gum, to prevent it from being injured or separated from and driven away from the necks of the teeth.

The form of the proximate surface of the teeth is such as to present an unbroken surface, that the greatest amount of trituration may be effected and that the food may not be forced between the teeth in a crude condition and to the injury of the gums. These forms, when carefully examined, will also be found conducive to the cleanliness of the teeth by the cleansing operation of use, as well as by the artificial aids to cleanliness which the intelligence of man may have added to natural influences.

It has been assumed by many that some alteration is necessary to these forms to prevent the recurrence of caries—more particularly with reference to the proximate surfaces of the teeth. The teeth have been separated by narrow and by wide V-shaped interstices on the assumption that contact is the greatest predisposing cause to decay of these surfaces. The usual result has been that, if the carious action had extended to the cervix, the teeth closed again at the apex of the space, rendering caries equally liable immediately below this point of contact, and that previous to the time of closure the food has been forced against the gum, to its injury, and often to such a degree as to prevent the subject of such spaces from effecting proper mastication. If the carious action has been arrested before the injury has reached the neck of the tooth, the result usually is better; but when the teeth are soft, caries is liable quickly to happen near the gum.

The teeth have been widely separated on the inner aspect of the interstices on the ground that the food, in sliding over these inclined surfaces toward the inner part of the space, would keep the interstices cleansed, and thus check decay from occurring; but in this case the teeth have closed, have often turned on their axes, and have presented flat surfaces so related as to favor the occurrence of caries more than the natural forms. By these means it has been sought to establish preventive measures by the production of unnatural forms. It has not sufficiently been taken into consideration that the recurrence of the carious action about the fillings is largely due to improper preparation, the crude packing of the cavity, and the imperfect finishing of the interstitial surfaces. Nature has been blamed rather than man. The restoration of the form of the tooth has too often been considered by those practising it as an æsthetic idea, rather than a following of natural forms because the highest use and longest preservation of the teeth are involved in these forms.

It will later occur in place to describe how to restore the form of the lost tissue and by what means to effect it.

The restoration of broken-down teeth for the purpose of again placing them in a state of usefulness was from the earliest times executed in plastic materials, but by the older methods of packing gold it could not have been attempted with more than a limited degree of success; but when crystalline gold was introduced, the way became plain and the plan was at once pursued. As previously stated, the most notable examples of such operations were those by Dr. Dwinelle, many of them being remarkable specimens of labor and skill.[1] When cohesive foil came into use, still greater facility was offered for carrying out the same end.

The date when and by whom attention was first called to the prophylactic value of the truly contoured filling has not been clearly determined; the mode of practice appears to have been a gradual development which had grown out of the failure of the interstitial self-cleansing theories. But by whomsoever devised and by whomsoever advocated is of little concern, in view of the fact that the most intelligent and most careful have come to the conclusion that the method is the most practical and the most promising of durable results.

It should be stated, however, that to the late Dr. Varney belongs the credit not only for the most artistically produced expression in gold of the natural forms of the teeth, but of having a clear conception of their prophylactic value. The fillings of the late Dr. Webb in this connection are notable instances of the fulfilment of the same ideas, as well as the remarkable fillings of Dr. Shoemaker, which in shape and elements of durability are unsurpassed.

Density of the Mass.—The degree of density of a filling is a variable element. For certain purposes great density is an indispensable advantage, and in some cases it may become a source of injury to the tooth. Where the fillings are subject to direct occlusion of the other teeth or of fillings in antagonizing teeth, the surfaces at least are required to be dense and hard; also, when portions of the teeth are built out to restore their usefulness, such portions have need to be solid. This also involves as a condition that the base of the filling in which the extended portion is established should also be nearly as solid.

When the pulps of teeth are comparatively near the surface or when the teeth are supersensitive to thermal changes, great solidity of the gold is frequently injurious, and may lead to congestion of the central organ. In such cases, however, whenever practicable, these influences may be limited by proper procedures.

When the teeth are hard, density of the gold may be attained with much less danger of injury to the structures of the tooth than when the enamel is soft and fragile and when the dentine is of low organization. When these conditions exist and no necessity arises for building out the fillings, non-cohesive gold, carefully introduced, offers the advantage of being varied in density, and yet is capable of being placed in perfect contact with the margins. This opportunity of varying the condensation of cohesive gold exists to a limited degree only, since cohesion cannot be properly secured without perfect contact. To make contact also involves the application of force in such a manner as may be injurious to soft

[1] *American Journal of Dental Science*, vol. v., New Series, 1855, p. 270 *et seq.*

teeth unless the electrical mallet or its equivalent supplies the percussion.

From the foregoing statement of general principles it appears that the introduction of the filling material is effected by two general modes of applying force—by hand-pressure, and by malleting. The former came into use in the early and primitive period of dentistry; the latter has grown out of the recognized necessity for dense fillings and operations of higher quality than could be effected under the older processes, and is inseparably connected with the use of cohesive gold, although not necessarily confined to it.

Hand-pressure, when judiciously applied with instruments of suitable forms, and when advantage is taken of the two mechanical forces alluded to, is, and must continue to be, an important and indispensable means of introducing many fillings. A certain portion of the gold in all fillings is manipulated in this manner by many expert operators. As greater tact, finer touch, and closer calculation of force are required in skilfully using hand-pressure, much experience is needed to become expert in operating in this manner. Each movement of the hand in placing and consolidating the gold is composed of three steps, each following the other in quick succession; these are distinct and limited, and yet to the ordinary observer they appear as one movement. The plugger, after taking up the gold and carrying it to the proper place, is projected forward, moved sidewise, and by a quick tilting motion of the instrument the consolidation is effected. The first movement carries the gold to its seat; the second prevents the instrument cutting through it, and also conveys the gold toward a margin or any desired part; and the third movement is one of leverage, which, being one of the powerful mechanical forces, is more efficient in effecting consolidation than the greatest amount of direct force applicable could possibly be.

While the movement producing the leverage of the instrument is slight, its effects are considerable. The analysis of the combined forces is this: The forward movement, in conveying the gold, wedges aside or apart the previous layers, and as the movement of leverage occurs one corner of the point becomes a fulcrum; the remainder of the point forms the short arm of the lever, which increases the penetration and the interior consolidation. At the same time the side or edge of the blade, as the case may be, continues the leverage upon the more superficial portion of the gold, and thus its consolidation is effected.

These three movements have to be adapted in their force to the position and the strength of the walls of the cavity, and their effects are qualified by the amount of material being carried before the instrument and by the physical properties of the material. It is obvious, that if the amount of the material is large, the force will be distributed throughout it and the effect at its outer layers will be less than if the mass were smaller. It is also equally clear that if the gold were of a hard character its unyielding nature would not permit the same degree of solidity to be secured as if its properties were soft and plastic.

The best results of hand-pressure are effected in the use of non-cohesive gold and with tin foil, for with these materials the powers of

wedging and of leverage can each be brought into play, and by these means considerable masses of gold may be packed very solidly and with rapidity.

To derive the greatest advantage from this method, the teeth should, however, be of firm texture and have margins of good strength. This means is therefore better for crown, buccal, and labial cavities than for those of proximate surfaces, for the reason that the force can be employed in every direction. It will, however, appear later that for the primary half of large proximate cavities hand-pressure can be used to great advantage.

Considerable experience is required to secure the highest efficiency with this method of packing. The movements of the hand are more complicated, and the calculation has to be made coincidently with the motion; hence novices, unless they have had proper previous training of the hand, content themselves with simple forward direction of force.

There are necessities, however, which should lead all to cultivate this method, since by the combination of hand-force and percussion better results can be attained than by either alone. Although hand-force is better adapted to non-cohesive gold, it is not necessarily so restricted. It has been shown that great force is not needed to bring about the cohesion of gold when it has been correctly prepared.

The mode of applying force to the instrument is here somewhat different from that described above. The gold is laid upon the part with some direct pressure, which is immediately followed by a tilting or rocking movement of the instrument. This produces leverage, in which one corner of the instrument is the fulcrum, and the other, coming down with energy, overcomes the irregularities of the surface, and also produces contact, and, therefore, union.

Percussion.—The exact time when percussion, as now practised in packing gold, came into use is not clearly known. The first publication upon the subject was made by Dr. Atkinson in 1861; in this he gives to Dr. E. Merritt the credit of applying the mallet in 1838. Its use at so early a date must have been a revival of the malleting process as a means of consolidating gold fillings after the packing process was accomplished, which was done for this purpose by the dentists of the earlier part of the century, and was by them abandoned as being the alleged cause of injury.

The method of malleting in the manner and for the purpose for which it is now employed came into use about 1856, which was shortly after the publication of the means of using adhesive gold, and was a necessary adjunct which naturally grew out of the necessity for securing additional and reasonable means to produce adaptation and contact.

Percussion for packing gold is effected by the following means—viz. the hand-mallet, the spring mallet, the electric mallet, and the mechanical mallet.

Of hand-mallets there are several varieties—those of ivory, of steel, and of lead. The ivory mallet, which was at first much used, has given place to the others named. The qualities of the steel mallet, mechanically considered, adapt it to produce the best results. The blow has sharpness; and when used with quickness and the proper degree of

force, gold is condensed with great solidification. It possesses in an eminent degree the quality of intensity, and permits the element of velocity to be employed (which farther on will be illustrated).

To make correct blows with the steel mallet the weight of it should be adapted to the size and weight of the plugging-instrument. When the instrument is small, the mallet should be light, and the converse rule is applied when the instrument is heavy. The blows should be very short, but delivered with quickness, to impart an impact having velocity.

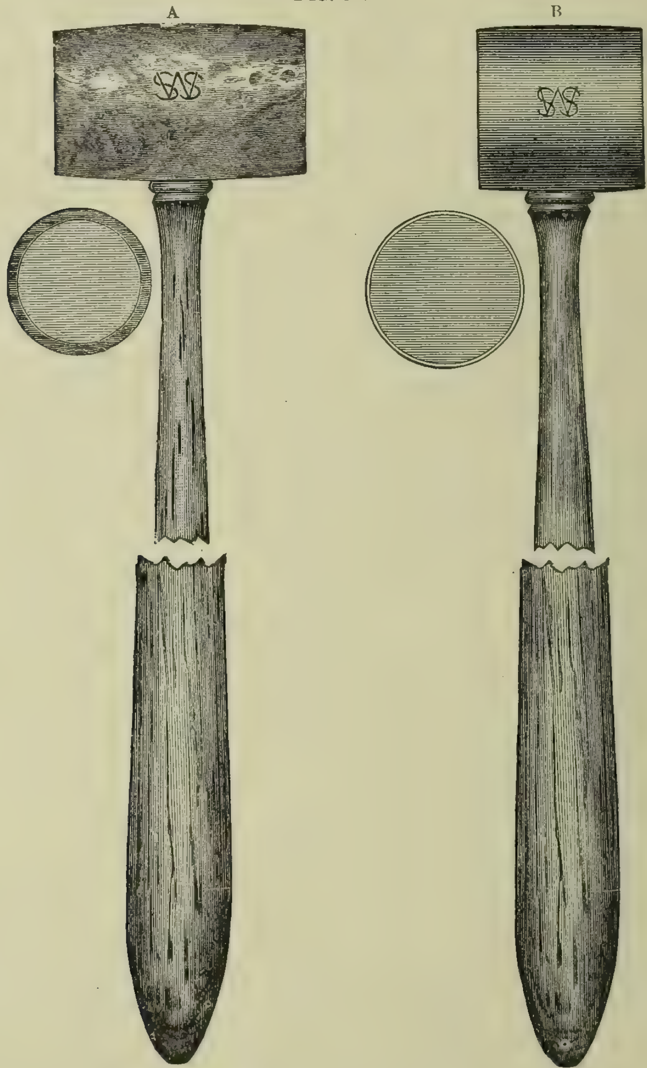
The packing of gold by the hand-mallet at the base and interior of the filling is best effected by taking up with the instrument the gold, carrying it to the desired place, and making one or two blows at each point where the instrument is placed. In principle one blow in each position should be sufficient, but in practice it is found that the second blow increases the consolidation, the force of the first blow apparently being taken up in overcoming the inequality of the surface. When, however, the gold has advanced toward the finish, the instruments being of finer surface, one blow at each place is usually sufficient, and to be effective this should be graded by the amount and the known character of the gold beneath the instrument. It should be noticed that velocity of a light impact is most important. An excellent manner in which to hold the instrument in this stage is to make a rest by the third finger upon some convenient part, holding the plugger with a spring of the finger in almost immediate contact with the gold, at each blow shifting the position. The point of the instrument then moves over the gold like a pen on the paper in writing. The movement is somewhat like that to be described for the handling of the electric mallet.

Considerable caution is required in using hand-mallets. The instrument, in starting the case and at all stages near the margins, should be cushioned by a sufficiency of gold to prevent the shocks from being expended upon the tooth. Not only is this the case, but after the work has commenced the blows should be short, light, and quick in preference to long or heavy, since the latter will at last impress their momentum upon the tooth, and, unless the structure be unusually dense, some injury may be inflicted. It is also obvious from this statement that malleting by any method should terminate at the moment the ear detects the evidence of sufficient solidity. It should also be noticed that the degree of solidity ought to be varied somewhat according to the character of the tooth-structure. By disregard of these conditions considerable injury has been done, and many an otherwise well-planned operation has proven a failure. The teeth have been over-malleted. This has been particularly the case where gold of hard quality has been used instead of that having soft properties. It will readily be seen how different must be the impression made upon the tooth if tin be malleted against its walls instead of gold; and when it is considered that there is as great difference between some specimens of gold and others as there is between tin and the softest and purest gold, the force of this caution will clearly be seen.

The lead mallet is used to produce what is called the "dead" blow, and, without being founded on the most correct mechanical laws to produce a given degree of solidity, it has grown in wide use because it is

more agreeable to the patient, and for the further reason that it is a safer instrument in the hands of the unskilful. It possesses, however, abundant percussive effect on cohesive gold, and is better adapted than the steel mallet for packing non-cohesive gold. Lead mallets are

FIG. 81.



usually encased in briar-wood or in a shell of steel, and are shown in Fig. 81; A represents Dr. Butler's lead mallet encased in wood; B represents a lead mallet encased in steel.

Shortly after the revival of the use of the mallet automatic devices to produce percussion were introduced, the first in order of general useful-

ness being the spring mallet. In this kind the force employed is that of the immediate resilience of a coiled spring, the blow from which is delivered with great velocity. The result is altogether due to the suddenness of the impact. Of the several which have been invented, the instrument which has given the widest satisfaction is the Snow & Lewis automatic mallet. It is capable of being adjusted from light to heavy blows, and is, all things considered, the most useful dental mallet which has been devised.

An important caution in reference to the "automatic mallet" should be enjoined. It possesses very considerable penetrative power, and for this reason the plugging-point should not be sharp or wedge-shaped except for special purposes; otherwise, the effect upon the gold is to unduly expand it, and in the case of weak teeth the margins may be checked. It is not impossible to so far expand a tooth by this instrument used with acute points as to crack the enamel of hard and strong borders. Points similar to those of Varney's have the best adaptation. The blow possesses the combined elements of velocity imparted by the resilience of the spring and of momentum given by the spring to the steel plunger, which plays freely in the barrel and is discharged upon the end of the instrument at each action. Its penetrative power eminently adapts this mallet to the filling of retaining-pits for the impaction of gold along the cervical walls when it is not easy to use the hand-mallet, for building up cases with cohesive gold after the establishment of the filling by hand-pressure or the hand-mallet. It is therefore an indispensable instrument, and when not applied with too much force is generally better borne than any other form of mallet. While the instrument is capable of rapid efforts, it is also adapted to cases requiring slow and deliberate action, as in starting retaining-pits, cervical borders, and intricate places. The instruments for this purpose, as previously indicated, should be comparatively broad and have the finest serrations, and where the face of the point is nearly transverse to the shaft the working surface is better nearly smooth.

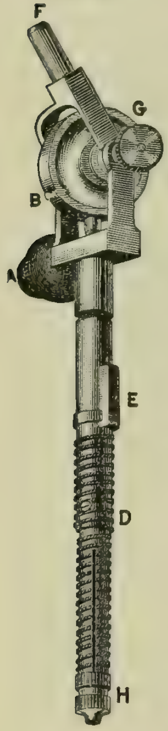
There are two circumstances under which the working-power of this instrument is diminished. When it is held in a horizontal position, the increased friction caused by the inertia of the plunger on the side of the barrel reduces the force of the action; and when it is held against the napkins at the side of the mouth, friction becomes an impediment. To lessen the latter the sockets should be kept in light contact with the environment. To obviate the former objection, the plunger and all the working parts should be kept well oiled.

The mallet next in order of penetrative power is a mechanical one operated by the eccentric action of a revolving disk of metal upon the edge of which is a cam. While this form of instrument is called a mallet, it is readily perceived that the force produced by it is not percussive, but is caused by the instrument being pushed forward a definite distance with great suddenness. The eccentric is a quickly-moving one and acts as a wedge rapidly driven against the end of the instrument; for this reason it has a marked penetrative force to the extent of the propulsion, and the result is, consequently, less disagreeable than it would be if effected by direct percussion with as much force and with the same

rapidity. The earliest recorded instrument of this character was invented by Dr. Buckingham. This is attached to the dental engine.

Fig. 82 shows Bonwill's mechanical mallet. It is observed that the power is transmitted to the plugging-instrument by the eccentric (B) on the wheel (G), which is driven directly by the cord of the dental engine running in a grooved pulley on the same shaft with the disk.

Fig. 82.



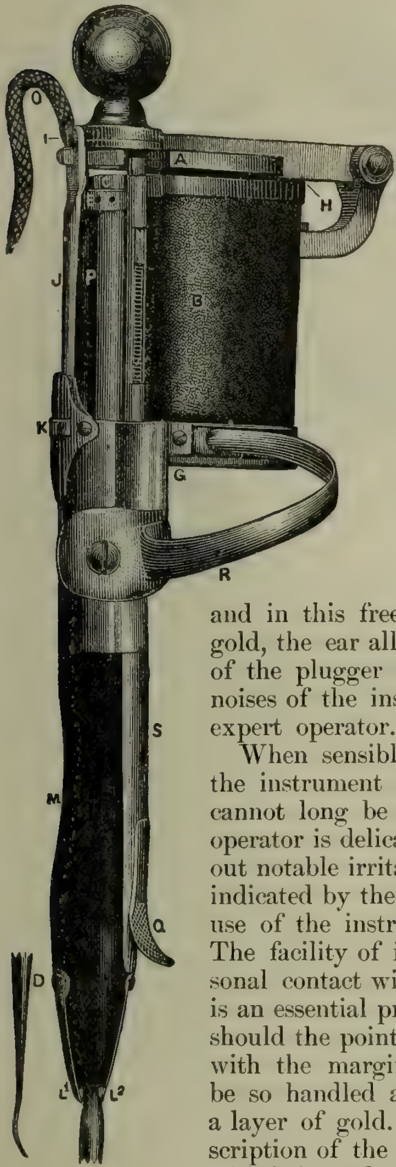
The superiority of this instrument consists in the suddenness of the propulsion and the rapidity with which the movements are effected, they being not less than from fifteen to twenty per second at the ordinary rotation of the engine. The result is that cohesive gold can be packed with great rapidity and with very considerable solidity. The complaints of the patients after they become accustomed to the great velocity of the impacts are less than in most other forms of effectual malleting. The instrument is not capable, however, of being used in all positions, but has the great value that none of its power is lost by friction against the napkins or side of the face. The instrument-points for this mallet should be broad rather than sharp, and, as is obvious, it is well adapted for building up cohesive gold, with which it may commence at the base of the cavity and be continued to the end if need be. The manner of using it is to establish each piece of gold by a few well-directed impacts and complete the condensation by a skimming movement over the surface of the gold, the index-finger at the time retracting the chuck-nut (H) of the hand-piece. This holds the instrument against its back-stop, prevents recoil, and keeps the point free of the gold during the interval, and therefore capable of lateral movements.

Recently, Dr. Register has improved the eccentric of Dr. Bonwill's mallet by having it revolve in a hardened steel bearing like a friction-roller; this avoids friction of the eccentric. He has also notably improved the instrument in other respects.

At an early date after the percussion of gold came into much use, the capabilities of electro-magnetism to produce a sudden movement of an armature suggested that the force of magnetism might be made available to produce actual blows upon a dental plugger. For this purpose several instruments have been invented; of these only one has thus far proven to be entirely efficient. It so happens that the organization of this one is so correct that it only remains to be improved in some of its minor working parts. This mallet is of Dr. Bonwill's invention, and is shown at Fig. 83. It has become so familiar in dental literature that an extended description is unnecessary. The blows are made directly upon a prolongation of the plugger by the armature, and by automatic devices the current is opened at each impact and closed at each recoil of the armature head. The blows are repeated as often as the mechanical movements can be effected, which occurs at intervals of about the fif-

teenth of a second. As there is scarcely any friction to be overcome, and as the action of magnetism is exceedingly quick, the blow has eminently the most important quality of velocity. It is for this reason that the blow of the light armature of this instrument is so powerful. The impaction of gold by it exceeds in solidity that produced by any other means. If the faces of the instruments are fine or nearly smooth, the state of the gold, if cohesive, is one of absolute solidity. The point of the instrument is driven forward the merest fractional distance; hence it can be employed for packing gold against the frailest walls—against edges so fragile, indeed, that any other means would inevitably fracture them.

Fig. 83.



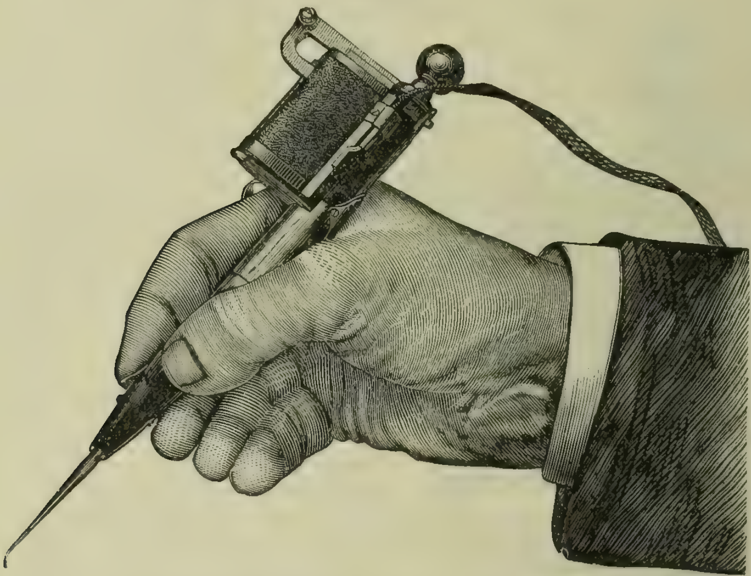
The instrument is held in the hand as it appears in Fig. 84, and is handled with a touch which is difficult in language to describe. The point is not applied to the gold with some pressure, as other instruments are, but is simply touched to the surface of the mass, and in this free state is rapidly skimmed over the gold, the ear all the while being guided by the sound of the plugger on the gold, which, among the other noises of the instrument, is clearly observable by the expert operator.

When sensible pressure is employed, the action of the instrument becomes excessively disagreeable and cannot long be tolerated; but when the touch of the operator is delicate, long operations are endured without notable irritation. The delicacy of manipulation indicated by the above language necessarily limits the use of the instrument to comparatively few persons. The facility of its use can be acquired only by personal contact with those skilful in its handling. It is an essential precaution that under no circumstances should the point of the instrument come into contact with the margins of the cavity, but should always be so handled as to be preceded by the presence of a layer of gold. For the reason just given no description of the particular manner of impacting gold with it is made.

The field requiring the employment of this mallet and the cultivation of facility with it is in the large contours and the necessarily exposed fillings of front teeth, which demand that degree of solidity which enables

the most perfect finish to be given to them. This instrument is well adapted to teeth of soft texture and of frail character, for the reason that the blows of the instrument are superficial in their effect; hence there

Fig. 84.



is no danger of the borders being injured by the application of its force, as may be the case when heavy hand-force is employed, or disintegrated, as when other mallets are used. The durability of operations so performed exceeds that attained by all other present methods. The certainty of perfect union with the orifice, if the general principles governing the packing of cohesive gold are fulfilled, and the great density of the filling, essentially contribute to this result.

The management of the galvanic batteries connected with the instrument has been considered an obstacle, but it is one which has no force with a properly-educated dentist, who should be familiar with all the chemical principles involved. Having this knowledge, there are no impediments to be encountered.

Fig. 85.

Form of Plugging-Points.—The form of the ultimate point adapted to hand-pressure is what is called the single-line point; this is represented by Fig. 85. It will be observed the point is a somewhat acute serrated edge, which is wedge-shaped, as shown. The purpose of the serration of the edge is to facilitate the picking up and conveying the gold, as well as to assist in inhibiting the penetration of the gold by the instrument.

The form of the blade, the bend of the shaft, and the size of the instruments are varied to meet the different requirements of the various

classes and sizes of cavities. The serrations may also be varied in depth and fineness.

The ultimate point used by some operators is as sharp and pointed as a needle—notably, the pluggers of Dr. Dodge and of Dr. Seymour. This form of point was first published by Dr. Arthur to be used in connection with heavy gold. The gold is conveyed to the part of the filling desired by a peculiar movement requiring great tact, and is condensed by leverage. This method requires much greater skill than the use of single-line points, but indicates that the sharper the points are made, the greater may be the density of the fillings.

Points for Malleting Cohesive Gold.—The general form best adapted to packing cohesive gold is the so-called foot-point. This may be varied in the general outline and size according to the extent and position of the cavity to be filled, but should possess two characteristics—viz. the working-surface should be slightly oval, and in the lateral direction particularly so. The relation of this surface in the greater dimension should be oblique to the line of force, and the working-surface should be finely serrated. The necessity for the ovality of the surface of the point is occasioned by several considerations. If the working-ing-face of the instrument is flat, it will be seen that if any penetration be made by the instrument the boundary of the depression so caused will be an acute one, this form necessarily requiring force and care to produce favorable evenness, failing which the filling may be deficient in homogeneity. If, on the contrary, the face is oval, the impingement is greatest in the middle, and the force is expended not alone in driving forward the instrument, but, what is of more importance, in producing some lateral or spreading movement of the gold. In the one case the tendency is to drive the gold before the instrument and to draw the neighboring gold toward this point; in the other the tendency is not only to condense the gold, but to force it away from the point acted upon. The importance of this distinction can scarcely be overestimated.

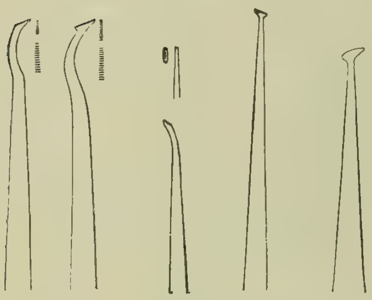
A further reason for this form consists in the consideration that in many cases the surface should be maintained in a concave shape until the margins are reached. This form of surface, combined with the designated shape, permits the points to be swept over any portion of the surface by the slightest movements of the hand. The importance of this appears more significant in relation to the use of the mechanical and the electrical mallet.

The reason for the oblique relation of the face of the foot-shaped instrument to the shaft and the line of force is to cause the gold to be driven in the direction of this obliquity. The chief end in view in this is to enable the gold to be impacted against the margins and to permit it to be worked over the edges of cavities. It is obvious, also, as will again appear, that this form greatly tends to overcome the crimping or withdrawing of the gold along margins when direct force cannot be brought to bear in a manner to overcome the above-named tendency. This form of the instrument becomes, in other words, the means of distributing the force imparted to the instrument to a part to which direct force cannot readily be applied. It tends to overcome the difficulties always encountered in filling the indirect positions. The degree of this obliquity may

vary, but should not exceed that given in Dr. Varney's No. 5. Fig. 86 shows several forms of foot-points.

An application of the principles connected with the foot-shaped point and the rounded form of the working-surfaces of this description of point will enable a proper selection to be made of the instruments best suited to be used for packing cohesive gold in any given case, and also to enable the force to be applied in such direction as shall with certainty effect the adaptation, form, and solidity of the stopping.

Fig. 86.



Serrations.—The purpose of serrations upon the working-face of the pluggers is principally to maintain a surface favorable to the adhesion of the gold. Theoretically, the gold should cohere as well to a perfectly smooth surface and be more solidly compacted upon it. This, however, is not the fact in actual practice, for the reason that the direction of the applied force cannot always be transverse, and for some effects should be oblique to the surface, and any sliding of the gold impairs the cohesion and sometimes requires the surface to be scraped before cohesion can be again depended upon. As the slightest roughness of the surface is all that is required, the serrations should be shallow ; if they are made deep, they impede the spreading tendency of the instrument and produce eminences which have to be broken down.

The first use of serrations is to aid in conveying the gold to the cavity. They assist in picking up the piece of gold from the napkin on which it lies, prevent it from falling off, and keep it in connection with the instrument during the lateral passage of the point to the portion of the filling it is to occupy. When the gold is non-cohesive, as has appeared before, leverage is an important application of force in producing the solid fixation of each piece. This requires that the point become fixed immediately before this movement takes place. At this moment the serrations assist in making the secure fastening required and prevent the point from cutting through the gold, which, if it does, tends to chop the pieces of foil and prevent their integration.

Another use is to diminish to a minimum the inhibitive effort required to keep the point from slipping out of its seat. Every such tendency causes abstraction of mind and prevents the concentration of force at the right moment, and hence every inhibitive effort is so much taken away from the force with which the instrument is applied. A number of writers have maintained the suitableness of smooth points, which for special purposes may often prove advantageous, but for general uses they appear to ignore, for the reasons given, some of the essential principles which tend to produce efficient placement of the gold and its firm condensation.

These objections increase when the instruments are to be used for packing cohesive gold, as a certain slight degree of roughness of the

surface, as has been explained, is required to enable the cohesion to take immediate effect.

Depth of the Serrations.—Those for cohesive gold should always be extremely shallow, not amounting to more than a slight roughness of the working-surface. If it were possible to maintain the crystalline surface of a piece of broken steel, this would be nearly sufficient. The serrations generally should be in only one direction, as their tendency is to detain the gold from spreading laterally beneath the applied force. This, however, appears less when the condensation is effected by hand-force than it does when the effect is produced by percussion. When the slight tilt or rotation of the instrument which effects the leverage is made, each serration, if the face of the instrument be not flat, becomes a new fulcrum the moment it has expended its effect upon the gold beneath it. The gold in this case does not move laterally; but when the force is percussive, if the serrations are in single lines, the gold moves in two directions: it is carried forward by the incline of the face of the working-surface if this be foot-shaped, and moves laterally at the same time in the other two directions if the face be slightly oval. These statements illustrate the value of the oval-faced foot-points. It will be observed that these facts have had expression in the form of many kinds of points long in use, such as Dr. Butler's, Dr. Chappell's, and lately in Dr. Bennett's; and by the latter the governing principles in reference to lateral spreading of the gold have been more explicitly stated than by any previous writer upon the subject.[1]

The oval form of implements used for extending the metals by hammering has been long in use in the mechanic arts. The form is not the segment of a circle, as most dental plugging points have been, but is composed of a flat oval for the most of the face, combined with a more abrupt oval at the sides.

Filling by Classes.

After the foregoing processes of preparation are completed, an investment of the tooth is made—by napkins for simple cases not liable to encroachments of saliva, and by the dam when any danger of moisture exists.

The cavity should be carefully dried and bathed with carbolic acid. The therapeutic use of carbolic acid is to limit secondary sensibility from becoming highly exalted. In many instances this form of sensibility, which is an expression of the irritation caused by the injury done to the dentine by the cutting instruments, become so intense as to induce considerable pain subsequent to the introduction of the filling, and sometimes necessitates the removal of the gold. Carbolic acid may also be of service in sterilizing the surface of the dentine, particularly if for any reason a portion of partially-decalcified bone is permitted to remain.

At the last moment the margins of the cavity should be illuminated and carefully explored, to determine whether at all parts the enamel borders are clean and well formed.

[1] "Principles and Methods of Filling Teeth with Gold," *Dental Cosmos*, vol. xxviii. p. 88.

Division I.—*Coronal Cavities.*—When these are of small size, they are mostly filled by wedging one or more small blocks of non-cohesive gold in one part, which, when secured, are followed by some pieces of cohesive gold that are incorporated with the surface of the blocks, when the remaining portion may quickly be completed by adding piece by piece of gold until the case is full at the margins. It should, however, be stated that the middle of the surface ought to be kept depressed during this procedure, the working going on more rapidly at the margins than at the centre, thus ensuring the gold being compacted against the margins. This method is well adapted to cavities having irregular sides and lateral extensions into fissures.

Another plan of filling the cavity almost entirely with non-cohesive gold is to insert blocks of gold around the margins, forcing them the while toward the borders. When the cavity is loosely filled, an opening is made by wedging down single-line points between the layers of gold and inserting one or more suitable blocks. This opening should be near the middle of the gold and may extend in an anterior-posterior direction nearly the extent of the filling.

By using the instrument as a lever the gold is forced laterally until great solidity is produced, since, as the gold is in vertical layers, there is no impediment to its consolidation. The opening is successively reduced in size as additional smaller blocks are added. At this stage the last portion of the crevice may be filled up with cohesive gold, a line-point being used for the purpose. The crevice may also be filled with mats of semi-cohesive or strips of heavy gold. It is scarcely ever necessary to expend the amount of time required to fill coronal cavities by small bits of cohesive gold piece by piece when by the above methods equally as good stoppings can be made in much less time. When, however, the cavities are large and the borders somewhat weakened, the following method will be found advantageous: If the cavity is of moderately large size, the bottom portion of it may be filled with non-cohesive gold in substantially the same manner as has been described, this portion of the filling terminating at the base of the enamel. The remainder may then be filled with cohesive gold, making the start of the cohesive gold in the crevice at the centre, or, better, incorporating cohesive gold among the layers of the lower gold before its consolidation is effected.

The incorporation of the two kinds of gold is effected as follows: When the base of the filling is composed of non-cohesive gold, as in coronal cavities and at the lower part of proximate fillings of the back teeth, it is generally necessary to complete the operation with cohesive gold. The combination of the two kinds of gold has by some been considered incompatible, but this is by no means the case if the procedure is properly conducted. The first consideration is that the basal portion of the filling be packed to a considerable degree of density by wedge-shaped instruments, which produces an irregular surface. While it is in this condition cohesive gold—preferably, No. 20—is worked into the surface by the same instruments, which forces the cohesive gold between the folds of the first and thoroughly commingles the two. Condensation may then be effected, when without the least difficulty any

form of cohesive gold may be continued to the end, which is reached when the gold has been brought slightly beyond the margin. The surface of the filling should be maintained of concave form, not only to facilitate the packing, but with the view of not impairing the function of mastication.

No instrument is so well adapted to impacting the cohesive gold and for condensing the surface in this class of cases as Bonwill's mechanical mallet. The automatic mallet is also serviceable. When the cavities are very large, the base of the filling should be composed of a hard plastic material, and then completed, as above described, by the cohesive method.

To fill simple strong-walled cavities with hard cylinders the space is loosely packed, then an instrument is thrust between the cylinders and is used as a lever to open a considerable space by forcing the gold sidewise. Another cylinder is forced into this opening. This action is repeated until the gold appears to have acquired adaptation and solidity, when further surface condensation is effected. Usually the cylinders should extend beyond the orifice of the cavity.

Labial Cavities.—Cavities of this class are usually not deep, and generally are not of great extent; nor are they difficult of execution by correct procedure. As, however, they are in an exposed situation, the fillings are required to be very neatly constructed. The gold should be densely packed and when completed have a beautifully finished surface.

The gold selected for this class should in all cases be of the soft cohesive quality. The reason for this is that this character of gold, when densely packed, is more nearly the color of the teeth, and, moreover, does not acquire a highly-burnished appearance by the friction of cleansing, as is the case when hard golds are employed.

Platinized gold, because of its slight grayishness of tint, is well adapted to bluish teeth. As this is made of several shades, it is not difficult closely to approximate the natural tint. This kind of gold is, however, only adapted to surfacing the filling, and should not be employed until the filling process approaches completion.

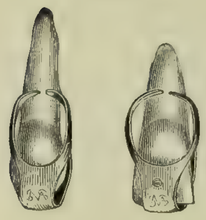
The variety of cavity which does not reach the neck is filled by commencing at a small retaining-point at each end and advancing from these along the retaining-grooves until it is felt secure to work over the whole area of the surface. The direction of application of the instruments should be toward the margins, and extreme care should be taken not to touch the edges of the enamel. The packing should be continued until the margin is slightly overfilled, after which it is readily reduced to a conformity to the shape of the tooth.

The variety which descends beneath the gum is more precarious, and a different procedure is required on account of the difficulty of controlling moisture. In many instances, if the cavity be for a moment filled with gutta-percha, the dam may be directed beneath the gum and passed above the margin of the cavity. The free ends of the ligature are joined by a knot a few inches away, and, this loop being held upward, the force carries the dam against the gum. The apposition of the rubber and the pressure used should exclude the moisture. It is generally necessary to have an assistant hold this loop in position. In

some cases the clamp represented in Fig. 87 may be advantageously used to hold the ordinary ligature in place above the cervical margin of the cavity.

In these cases the cervical margin should be more undercut than as described. The first piece of gold should be non-cohesive and be laid along the cervical wall, and while held in position with the left hand should have its inner border forced into the retaining-groove. When fixed in place, the outer extruding border is bent upward and made to press against the ligature. The opposite margin is covered in the same manner; and when both are secured, cohesive gold is incorporated with these at their base and gradually extended across the floor of the cavity. The process is then continued as before stated. In this manner this difficult modification may be successfully filled.

Fig. 87.



Buccal Cavities.—The filling of buccal cavities does not materially differ from that of labial cavities, the necessity for careful exclusion of moisture being probably greater here than elsewhere. In addition to a ligature to secure the dam, a clamp should be used to hold the ligature below the cervical margin and to somewhat press the cheek away.

The cavity is commenced at either the cervical or the distal border, according to the access of the case. If near the front of the arch, a good-sized block should be laid along the cervical border, and while held by the left hand be first fixed by the instrument in the right hand, and then forced against the margin. Cohesive gold is next incorporated and the cavity filled with it piece by piece, great care being taken completely to fill the retaining-grooves. If the cavity is situated in the second molar, it is generally necessary to commence at the distal border and advance forward; in this case a well-made retaining-pit is cut in this wall. If, however, this margin approaches the proximate surface of the tooth, it is necessary to place the means of retention in the upper and lower margins.

The completed form of these fillings should closely conform to the shape of the tooth. If they are convex, the bristles of the brush in polishing them glance to the margins and properly cleanse these important parts; if, on the contrary, the surface be flat or concave—as the older dentists often made these stoppings—the concentration of the bristles is at the middle of the filling.

Lingual Cavities of the Molars.—These are filled, when above, in a manner similar to the filling of the sulci. When situated in the lower molars, they are usually near the cervix, are extremely difficult, and when large should generally be filled with some plastic material. An additional reason for filling these cavities in this manner is that the pulps are comparatively near the inner surface of the lower teeth at this point. When small, the procedure is to fill with non-cohesive foil by wedge-shaped instruments, as the situation rarely admits of sufficient directness for the use of the mallet.

Division II.—*Proximate Cavities of Incisors and Cuspids.*—These are among the most important fillings required to be performed, since

they are so placed as to qualify the appearance and comfort of the teeth immediately connected with the expression of the features in a state of action, and hence, if they are improperly accomplished, may mar the appearance of the teeth and impair the harmony of the features. For this reason all stoppings of the front teeth should not be exposed if the avoidance of this is possible; and when for any reason it becomes necessary so to do, the form of the exposed gold should be in conformity with the shape of the teeth, and the homogeneity and finish should be perfect. When well performed, no class of cases are more durable, and none afford so much satisfaction to the patient as these.

It should be kept in view that retention of the ordinary stoppings of this class is effected by means of the concave inner surface of the labial enamel and the counteracting pit formed at the inner margin in the tuberosity or basilar process. It should be also observed that the direction from which the cavities are approached is the inside; to facilitate this, the lingual wall has been partially cut away.

This direction is considered the correct one, for the reason that the gold can be properly placed against the labial wall, and that the filling, when completed, will be less conspicuous than would be the case were the gold introduced through the front of the space.

Filling with Cohesive Gold.—The starting may be made by laying soft cylinders of semi-cohesive gold along the cervical wall, they being held in place until this wall is well covered and the gold secured in the labial cervical curve as well as in the pit within the tuberosity. Double-curved instruments similar to Fig. 88, of suitable size, are well adapted to introduce and force into place these pieces of gold. In case there is any threatened difficulty of retention, a small pit may be made in the outer third of the cervical wall. When this portion of the gold is secured, the remainder of the filling may be completed with pieces of cohesive cut ribbon of various widths, according to the size of the cavity. For small cavities the start may be made with mats, one or more being taken up in the pliers or upon the point and carried into position. During the packing of the gold care must be taken not only that the retaining-pit and shallow grooving in the lingual plate of enamel be completely filled with gold, but that the gold as it advances upward along the labial wall is somewhat carried over this margin. After the retaining-pits and grooves of each portion of the cavity are filled with the semi-cohesive foil and the incorporation of the cohesive gold is established, the instruments used should be small foot-shaped pluggers, the direction of the force being obliquely upward and outward. These pluggers, as has been described, tend to extend the gold against the margins.

Fig. 88.

When the cavity is apparently full, additional gold should be applied from the outer direction along the labial margin to secure such a degree of fulness there as will permit the gold completely to fill the countersink and slightly to lap over the margin, and yet this should be so little exposed to view as to be scarcely observable when the case is finished.

For the smaller cavities the automatic mallet is probably the most suitable instrument with which to pack the gold; when the cavities are large, either this, the electrical, or the Bonwill mechanical mallet may be used.

Filling with Non-cohesive Gold.—When the teeth are of good quality and the outer wall of sufficient strength, another and excellent method is to pack the upper third of the cavity with blocks or flattened cylinders of non-cohesive gold, and after lining the labial wall throughout its extent with the same description of foil to fill the remainder of the cavity with cohesive foil. This should be commenced as before directed by incorporating some No. 20 with the foundation-gold. This method is more rapidly accomplished than when cohesive gold is used throughout, and is equally efficient if properly done.

The general method of filling the cuspids is the same as for the incisors, the difference being in the external form of the filling, and not in the essential shape of the cavity.

When the labial wall of the front teeth is in part broken away, the remains are usually too thin to be of any service as means of retention. In this case the approach is made from the outer aspect, the inner wall in most part being permitted to remain. The gold is established in retaining-pits in the cervical wall and within the tuberosity of the inner border. The greatest care must be had thoroughly to compact the gold in these pits, for on them depends the security of the operation. After the foundation is established the case is completed by the slow process of adding piece by piece of thin layers of cohesive gold.

The instrument best adapted when the lingual wall is strong is the automatic mallet, the completion of the gold being made with the electrical or mechanical mallet. When all the remaining walls are weak, no instrument is so safe or reliable as the electrical mallet.

A not unfrequent modification of large cavities of the front teeth is the extension of the caries to the cutting edge, or the cutting edge may be cupped by attrition consequent upon the exposure of the dentine. In either case the dentine at the end of the tooth should be cut out and made continuous with the proximate cavity. This complication, while it frequently weakens the tooth, generally adds to the security of the proximate portion of the filling, since we are at liberty easily to make this portion retentive. The end of the tooth should be very slightly shortened in these cases and the groove of the cutting edge well countersunk, with the object in view that when the gold is packed it shall cover the end of the tooth, to protect the plates of enamel from the shocks of occlusion with the lower teeth.

When cavities of the proximate surface join labial cavities near the cervix, the most judicious plan is first to fill the labial cavity, and after packing the proximate case to join the two in one operation and at a single sitting. In this manner a homogeneous filling is effected.

Mesial Proximate Cavities of Molars and Bicuspids.—The introduction of the gold in this class is somewhat more difficult than in the preceding one. These teeth are, however, generally stronger, and, as more strength may be employed, the delicacy of manipulation demanded is less. It is a pertinent fact that a greater proportion of proximate fill-

ings of these teeth fail than of any other class. It would seem that, as the teeth are strong and comparatively near the front, failures should be less common than of the front teeth, for instance; but that the reverse is true is seen in the greater proportion of bicuspid teeth which are lost from the repeated failures of fillings in them. The reasons for this do not easily appear. The kind of fillings which are least successful in this class of operations, both in bicuspids and in molars, are the smaller ones.

When teeth are simply opened by pressure and allowed to come together again, or are cut apart in such a manner that they may come into contact as before, caries recurs, because the teeth are less perfect in many instances along the margins of the fillings, and, further, because conditions are restored which favor the occurrence of carious action. The only remedy which promises efficiency is included in what is about to be stated concerning the contour method.

This is an opportune place to direct more careful attention to the features of what has been called the contour system of filling teeth. In the consideration of the general principles governing the filling of the teeth it was maintained that when considerable destruction of tissue has occurred the necessities of function require that the loss be replaced by mechanical means. It is now to be shown that, in addition to this necessity, it is frequently admissible to remove a portion of the normal tissue, and afterward replace it as a means to protect the enamel of one tooth from coming into contact with that of the adjoining one. This method has been deemed the most promising one to prevent the recurrence of caries. It has been demonstrated that the plan of widely separating the teeth by cutting has been productive of injury and does not prevent the teeth from approximating. It has also been shown that when the enamel is permitted to come nearly into contact caries happens at this point whenever the conditions exist which favor the occurrence. To remove a portion of the enamel in such a manner that when the loss is restored by gold a permanent separation of enamel margins is effected is the salient feature of this rational course of treatment of proximate caries of the bicuspids and molars. There appears to be but one argument to militate against this method, which is the amount of labor and care involved and the degree of skill required to make the replacement of material. But when it is recognized that the labor of properly per-

Fig. 89.

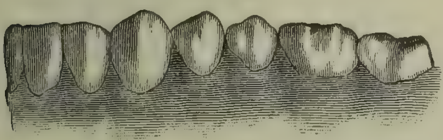
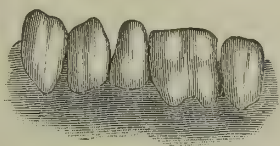


Fig. 90.



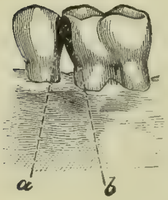
forming one durable operation is less than the several attempts which the opposite method necessitates, these objections cease to have any value.

The accompanying cut (Fig. 89) represents the form of the teeth when they are well separated at the neck, and indicates the necessity

for the restoration of the shape of the tooth to prevent the closure of the space at the gum which is shown to have occurred in Fig. 90 as a consequence of pursuing the opposite method. The latter case was taken from actual life, and represents the results of the older methods of treatment and indicates the consequences which followed this course during a period of about thirty years. It not unfrequently happens that the same results are in less than a ten years' interval brought on in both bicuspids and the first molar. Where several of these contiguous teeth are reduced in size and malformed by this method of treatment, the most advantageous course is to extract the second bicuspid and restore the form of the first bicuspid and first molar, when the gold will reoccupy nearly the whole of the space so made.

The case represented by Fig. 89 is one of not uncommon occurrence. In these cases the contour method involves but little more cutting of the margins than is required completely to remove the zone of imperfect enamel surrounding the cavity, and, in addition, to provide correct countersinking. This usually will bring the gold so near the margins as to produce the required separation of the enamel. Attention is again called to the additional cutting of the upper part of the proximo-buccal aspect of the molars, which permits the gold to be carried over the margins as it approaches the junction of this surface with the coronal surface. (See Fig. 91.)[1] The extreme necessity of careful attention to all the details required to give protection to the margins warrants the urgency here given to these points of the procedure.

Fig. 91.



It has been previously explained that the approach to the cavity has been secured by separation of the teeth by pressure and by cutting away a portion of the coronal plate of enamel. The space should be retained by means of gutta-percha until the day of filling, and may then be increased by a wooden wedge or by a Perry or Jarvis separator, and secured in a suitable manner.

The first pieces of gold are packed against the cervical wall, and should be held in place by the assistance of the left hand until secured in the lower ends of the retaining-grooves or in the pits when these are used. The importance of carefully placing and well condensing the gold about the cervical wall cannot be overrated, as the success of the filling depends more on this than on the packing of any subsequent part. The packing at this portion should be slowly proceeded with until the assurance is reached that this margin is perfect. After the first pieces are secured there is no form of instrument so well adapted to force the gold downward and over the margins as a foot-shaped plugger, of which No. 5 of Varney's set is a good example of size and direction of lines, but the working-surface should be slightly oval.

These first pieces of gold may be of a form in agreement with the habit or genius of the operator, but in all cases the principle is the same: the gold needs to be slightly fuller than the edge of the cavity and to be beaten somewhat over this margin.

In the older methods of operating this portion of the filling was left

[1] The filling at *b* should have been represented as extending into the coronal surface.

to the uncertain chances of the consolidation of the gold sealing it. In the newer methods the same difficulty exists, for, unless special care be taken, the gold will curl up at the edge, and may never be brought into exact contact again. Hence the advantage of foot-points at this stage, but their use also requires the most careful formation of grooves and thorough packing of the foundation-pieces of gold. Another danger in the newer methods is that of impairing the integrity of this margin by over-malleting, particularly when the harder kinds of gold are employed.

It is difficult to lay down with any degree of precision methods for overcoming the difficulties of perfectly packing the cervical border; they have to vary with the kind of gold used and the attainable form of the cavity.

When the gold to be used at the neck is non-cohesive, the cervical wall should be unbroken by either pits or grooves. After the first blocks are secured in place by hand-force they are malleted throughout and made to overlap the border; the next layer of blocks may be packed in the same manner. The commencement in each case is made by packing a block at either side and securing them by a larger one in the middle, which overlaps somewhat the first pieces. When the second layer is complete, cohesive gold is incorporated previous to the consolidation, when the case may be carried on as any ordinary cohesive filling. Particular attention must, however, always be given to keeping the surface of the gold somewhat concave and to so applying the foot-points as to overlap the margins as the advancement upward of the filling progresses.

Constant care is required to prevent the gold from acquiring too much fulness at the lower portion of the stopping. This is largely obviated by an avoidance of the use of too much gold at a time, by the employment of foot-points, and by the maintenance of slight concavity of the surface of the work. The use of certain forms of foot-points also aids in this stage of the case. The point shown at Fig. 92 may be stated as of the greatest service for packing cohesive gold, since it will reach all portions of the mesial surfaces from the direct line of approach, and may also be inserted from the buccal aspect to condense the overlapping gold as it advances upward, particularly in building on that part which replaces the mesial-coronal enamel and constitutes the portion of the filling which is intended to prevent the tooth-structure from coming into contact. The forms of points of Dr. E. Parmley Brown, represented by Fig. 93, are also well adapted for the same purposes as the last instrument described. They should not, however, be serrated in both directions.

Fig. 92.

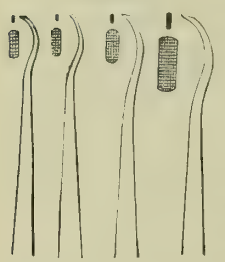
There is no particular difficulty in packing fillings by the contour method if the procedure here laid down is followed. It is simply a question of expenditure of time, and not one of great skill. That which has been a deterrent influence is the appearance of the necessity of unusual ability, whereas the plan is simply one which gives easy access and constant control of the course of the packing.

When the lateral walls are strong, non-cohesive gold may compose

the bulk of the filling, only a small part of the upper or coronal portion being made of cohesive foil.

When it is determined to use cohesive gold throughout, the commencement is made in a pit in the middle of the cervical wall. From this the gold gradually extends to the retaining-grooves in the lateral walls, when the case is proceeded with as above described, care being always observed to overlap the margins by means of foot-points.

Fig. 93.



An important means of adding to the security of these fillings is to extend them into the sulci of the coronal surface, which should be cut in such a form as to aid in the retention of the gold. In many instances these fillings have to withstand the shocks of mastication, and then, as has been pointed out, the inclusion of the sulci becomes an indispensable means of security.

An important feature of the mesial surfaces of both bicuspids and molars at the cervix is the general existence there of a fossa more or less deep. This fossa commences at the enamel and terminates at the bifurcation of the roots. There is liability of too much gold being permitted to remain here at the conclusion of the operation. This affords the opportunity for lodgment of sedimentary matter, which may induce solution of the tooth at the line of juncture of the gold and tooth. Special care is needed to avoid this occurrence. The presence of this fossa is one of the predisposing causes to the occurrence of decay at this margin of filled teeth of this class.

Distal Proximate Surfaces of Bicuspids and Molars.—This class differs from the former only in the greater difficulty of access in all stages of the case. There are, however, situations when the distal surfaces of the bicuspids are more easily operated on than the mesial aspects—notably, in the teeth of the left side.

To increase the accessibility, it has been shown that the coronal plate should be more cut away than for the mesial surfaces. In some cases it becomes necessary completely to do this.

The filling is conducted as described for the last class, greater care, however, being required at all steps of the packing, on account of the reduced facility of access and of diminished light. The mirror should be kept in constant use; and where facility has been acquired by practice, great advantage is found in manipulating to the reflected image instead of direct vision.

When the cavity is large, the mouth not flexible, or the cases are in the distal surfaces of the molars, attention is directed to the directions to be given later for the use of the matrix.

Division III. includes the various combinations of the union of proximate cavities with coronal, labial, and buccal surfaces. The most common modifications of these combinations are:

a. Proximate of incisors with labial;

b. Proximate of bicuspids and molars with buccal;

c. Proximate cavities of molars and bicuspids with coronal.

These combinations, since the introduction of cohesive gold and of the contour method, do not materially increase the difficulties of small cases over large simple cavities. They do, however, greatly contribute to the time required and to the exhaustive nature of the effort necessary to complete them.

In the case of labio-proximate cavities of the molars—which are, fortunately, uncommon—the outer plate of enamel is weakened and the opportunity for establishing the initial pieces of gold is diminished. The dependence must here be made upon a deeper and more securely shaped retention at the junction of the cervical and lingual walls.

The gold to be used when a matrix is not employed should be cohesive from the start, which is made in a retaining-pit, the gold being slowly and securely extended until it finds anchorage in the labial portions of the cavity.

The best method in these cases is first to fill the labial portion and join into this part the gold as the proximate portion approaches it.

The correct packing of the gold in this variety of compound cavities requires so much time and is so exacting of care and strength that this procedure is rarely well performed. It is not, however, because of insuperable difficulties. The general method previously given is applicable to all the combinations. Of cases involving the communication of coronal cavities with proximate, the elements of the cases are generally simplified, however much extended. Where very large the interior portions of the cavity should be filled with one of the hard, earthy plastics, to conserve the strength of the tooth and diminish the labor required. The packing should always commence at the cervical wall and be extended into the coronal portion as that may be reached.

The inclusion of this part as an integral portion of the filling greatly adds to security of retention and to the durability of the operation. The packing of the proximate portion may be by any of the means previously described, but the coronal portion should always be of cohesive gold. In small cases every advantage should be accepted of filling the sulci to give greater stability to the case, caution, however, being observed to avoid cutting wide or deep channels for this purpose.

The Use of the Matrix in Filling Teeth.

Matrices of several varieties have grown into successful use as aids in packing the gold in proximate cavities of molars and bicuspids and in producing fillings correct in form. Their purpose is to facilitate the operation by converting a difficult and complicated case into a comparatively simple one. The elements of a proximate cavity are changed into the principal characteristic of one on the coronal surface; and when the directions are faithfully fulfilled, the changed relations ensure a simpler performance, and as reliable results are secured as by more tedious and greatly more difficult procedures. The salient feature of the method about to be described consists in the envelopment of the whole or a part of the tooth by a metallic encasement in such a manner as to furnish a provisional and temporary wall circumvallating the natural opening of the cavity.

The difficulties connected with filling the proximate cavities of molars are comprised under three heads—viz.:

a. The uncertainty of producing proper solidity and exact fulness at the cervical portion of the filling without some injury to the integrity of the tooth-border;

b. The indirect approach to the lateral walls, combined with some danger of weakening them by force when wedging and leverage are resorted to;

c. The difficulty and irksomeness of the procedures necessary to restore the form of the tooth when it is desirable that it shall be built out by the use of cohesive gold exclusively.

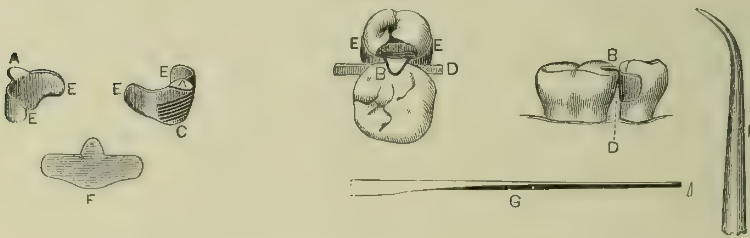
All these difficulties and impediments are enhanced if the cavity is upon the distal surfaces of the posterior teeth, and it is in these parts that the aid of the matrix is eminently called for.

The original suggestion for these appliances was made by the common use of pieces of files, which, being badly adapted to the purpose, led to the improved inventions in this direction. The first published use of any form of matrix was by Dr. Dwinelle; he employed a hard piece of gold plate wedged against a molar to form the anterior face of a large filling.[1] This was substantially a band matrix, and was frequently afterward imitated by the use of the blank ends of files or pieces of silver, as above stated.

The forms of matrices thus far introduced are the clasp, the band, and the depressed.

The clasp matrix of Dr. Woodward is shown in Fig. 94. This rep-

Fig. 94.



resents the form in all its parts, with some of the accessories. The blank F shows the form of the metal before bending. The convex lower border coincides with the cervical line of the cavity; the projection of the upper border is to form the lug A and B, which in use prevents the appliance from passing too far downward or from being driven out of place. The two ends E are bent to the shape of the tooth, which they should embrace with an amount of pressure sufficient to spring the face of the matrix clear of the cervical margin of the cavity. It is obvious that the edge adapted to the cervical margin should pass slightly beyond this point. The steel blanks should be No. 28 thickness for small bicuspids, No. 27 for medium-sized, and No. 25 for the molars.

After the adjustment of the form of the matrix to the case it is grooved to make little sharp ridges inclined toward the coronal edge

[1] *American Journal of Dental Science*, vol. v., New Series, 1855, p. 285.

to prevent the slipping of the wedge used to secure the matrix. It is then hardened, drawn to spring temper, and the face side polished, to reflect light and facilitate the packing of the gold. When adjusted, it should be a little clear of the cervical margin and have sufficient spring to pinch the wedge, so that with the aid of the grooves it may be retained.

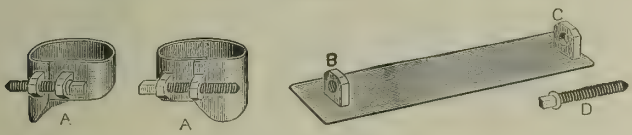
The form of the wedge is a double one, as shown in the cut, which permits adjustment in both directions by one movement. These are best when made of boxwood, on account of its resisting qualities.

To make correct adjustment of these matrices, the teeth should be pressed apart enough to allow for the intended convexity of the filling and the thickness of the matrix. After the removal of the matrix the teeth immediately spring together, as in the packing process they have been driven somewhat more apart, but the opening between them may be made sufficient to do the finishing by the use of screw separators, or a space may be effected for this purpose by the swelling of cotton tape.

The band matrix of Dr. Woodward is intended for bicuspids and molars when the whole or large portions of them are to be restored with comfort and speed. It is obvious that the clasp matrix is not adapted to cases where the margins are broken away and much impaired by extensive caries, and the same should be stated of the depressed matrix. As there are decided indications that the use of various forms of matrices are destined in many cases to supersede the slower and more uncertain methods of operating, an extended quotation from Dr. Woodward's explanation of his band matrices will not be out of place:

"A, A, Fig. 95, represents the band matrix. It is almost indispen-

Fig. 95.

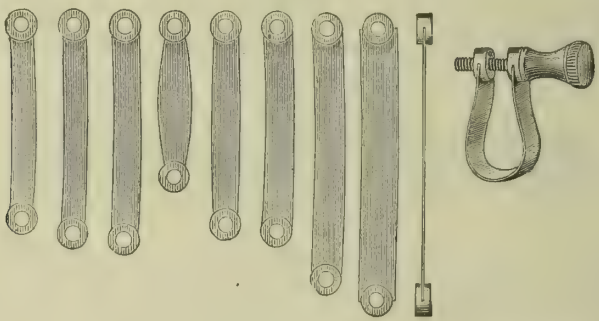


sable where large fillings restoring the whole or parts of the crowns of molars and bicuspids are to be quickly and comfortably inserted. An impression of the tooth for which the matrix is to be made is taken in modelling compound. A piece of straight-grained pine wood about four inches in length and a half inch square is next whittled and filed to fit the impression, and should taper slightly, so that the matrix will have a little less diameter at the cervical edge. A strip of phosphor bronze, No. 30 standard wire gauge, as wide as the matrix is intended to be, should be bent around the pine stick and overlap about one-sixteenth of an inch. The threaded post should be set with binding wire or a clamp made of piano-wire about one-eighth of an inch from one end, B, of the strip of bronze, and soldered with silver solder. The post in which the screw turns free is set near the other end, C. The distance the post B is from the end of the strip is the amount of variation in the size of the matrix. German silver No. 16 standard wire gauge answers nicely for the threaded post; the other post may be lighter—No. 19. The screws are of steel and have a square head which will fit a large-sized

watch-key, which after filing off the ring may be fastened in any kind of a handle. The screws should generally be about seven-sixteenths of an inch in length over all, D. When the posts have been soldered, the matrix should be bent around the pine stick and secured with the screw. The cervical margin can now be trimmed to follow the line of the gum with a corundum point or finishing burr, and the matrix polished. The threaded post must be set distally, so that the screw-head may be directed mesially, and it is most conveniently turned with the key when it is on the buccal surfaces of the teeth. The cervical and all margins of cavities which will come close to the matrix are best prepared before the matrix is adjusted. This done, the matrix is secured on the tooth by closing the band with the screw, after which the rubber-dam is passed over it and such adjoining teeth as may be thought best. The dam will readily pass between the matrix and proximate teeth, and with little discomfort to the patient can easily be carried below the cervical edge of the matrix. The preparation of the cavity can now be completed. The bronze, being soft and tough, can be burnished to mould the filling as the conditions present demand, care being taken that a little space is left to allow the filling-material to overlap all margins. The removal of the matrix requires no particular care. The screw is disengaged from the threaded post, the ends are spread apart, the matrix is pushed slightly toward the tongue, and is then easily withdrawn."[1]

Fig. 96 shows Creager's band matrices. These are made of very thin

FIG. 96.



steel which will pass into minute spaces and are of varied lengths, each bar having two heads upon it, to be connected by the thumb-screw shown in the cut. When put in place, the heads are drawn together until the tooth is closely embraced. This form is not, however, very well adapted to cases which extend beneath the gum. A modification of this form could easily be constructed which would overcome the objections. It would be preferable in some instances to have this kind made of phosphor bronze.

Fig. 97 represents Dr. Guilford's band matrix, which is an improvement of Dr. Huey's and Dr. Creager's. It is planned to avoid the necessity of passing it through two interdental spaces. Its field is also to aid in packing isolated teeth, loose teeth, and the distal surfaces of the wisdom teeth.[1]

[1] *Dental Cosmos*, June, 1885.

[1] *Ibid.*, vol. xxviii. p. 140.

Fig. 98 represents Dr. Brophy's loop matrix. This has the same use as Dr. Guilford's. The adjustment to the form of the tooth is made by turning forward the screw.[1]

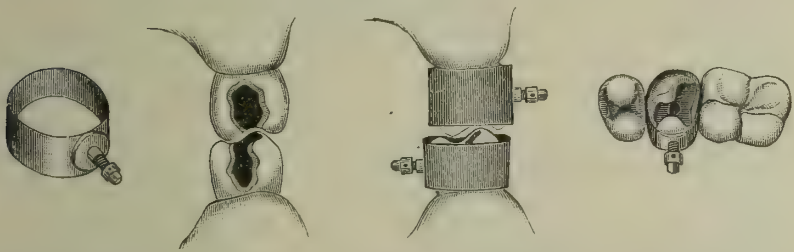
Somewhat similar to these last described are some forms of the

FIG. 97.

matrices used by Herbst and Bödecker in connection with what has been designated the Herbst method of filling teeth, to the paper on which the reader is referred.

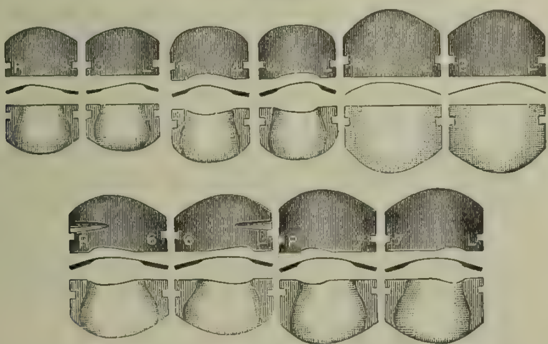
The depressed matrix, shown at Fig. 99, was the first step from the crude form of the bent piece of file. These are formed of steel of varied sizes

FIG. 98.



and shapes, having on the face surface a depression, as represented. The purpose of this depression is to produce a certain degree of fulness of the surface of the filling near the margins—partly to effect the general convexity of the surface of the filling, and partly to ensure the neces-

FIG. 99.



sary fulness of gold along the lateral margins of the cavity. It will also be observed that the general form is curved, to still further increase the convexity of the filling. These matrices may be changed in form

[1] *Dental Cosmos*, vol. xxviii. p. 293.

at pleasure by drawing the temper and further bending the appliance to any degree of concavity requisite.

The form of the outline of the depression corresponds to the usual form of completed cavities, and the shape at the cervical edge is such as to adapt it to pass beyond the margins of the cervical wall.

The preparation of the cavity differs but little from the description previously given of proximate cavities of molars and bicuspids. The coronal wall is cut away somewhat more, the lateral grooves are a little deeper, and the margins of the cavity are thoroughly polished. In most cases it is an advantage to polish the whole interior of the cavity with an orange-wood stick armed with pumice, since the smoothness of the surface facilitates the movement of the gold and permits an easier and better consolidation of it.

When the lateral walls are weak, their coronal ends should be cut down that they may be covered and restored by cohesive gold.

The selection of a suitable matrix for any case requires that regard be had to the lateral and vertical dimensions of the cavity. The distance from side to side of the depression should be slightly greater than the width of the cavity from the limits of the margins of the countersink. The dimensions in the vertical direction should be sufficient to permit the cervical border to be slightly passed, while the other edge of the matrix should coincide with the coronal surface. In case the matrix is not in close proximity to the tooth along the cervical face, the matrix should be fitted by bending it. This is easily done by removing the temper and hammering the part upon a piece of soft metal.

Previous to the final adjustment of the matrix the tooth with its neighbors should be environed by rubber dam, which usually should be secured by ligatures.

The Fixation of the Matrix.—The matrix is secured in place by means of the double wedge previously described.

The form of the space between the teeth near the cervix is such that the space is wider at the gum than near the masticating surface. This form should be maintained throughout the treatment of the case.

Previous to inserting the wedge it should be dipped in a solution of gum-sandarac in alcohol, of the consistency of simple syrup, which materially aids in securing both wedge and matrix from any subsequent movement. The first wedge is forced from the buccal side while the matrix is held in position with either the pliers or the fingers. A second wedge is next forced between the matrix and the adjoining tooth at the space which exists at the inner side. It will be observed that in the preparation of proximate cavities the separation is somewhat greater on the inner side, which makes the necessity for a wedge to be inserted at this point. Fig. 100 and Fig. 104 represent a depressed matrix fixed in place.

Dr. Darby has devised a form of screw wedge, shown at Fig. 102. This may be adapted to the fixation of any form of matrix.

Fig. 103 shows the form of the matrix-pliers, which are useful in making adjustments and for the removal of the matrix.

When the cavity is viewed from the coronal aspect after the matrix is

put in position, it does not materially differ from an ordinary coronal cavity in its elements, which is shown by Fig. 104. If the space be perfectly filled at all parts, when the temporary wall of steel is re-

FIG. 100.

FIG. 103.

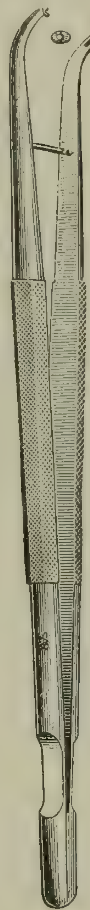


FIG. 101.

FIG. 102.

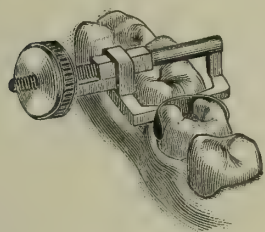
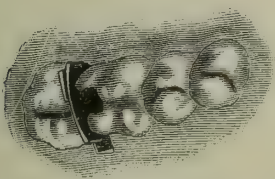


FIG. 104.



moved the result should be the same as if the case had been filled with all the advantages of easy access without the matrix.

It happens, however, that it is an extremely difficult and tedious matter to fill the large distal cavities of the posterior teeth by the ordinary methods, and, as stated before, this means is intended to overcome these difficulties.

If the cavity be viewed from the proximate direction, it will usually be found to present somewhat the form shown in Fig. 101. This form is such that a filling introduced into it could not escape toward the coronal direction, because the cavity is narrower there than near the gum. If the retaining-grooves have been cut sufficiently deep, it is held from

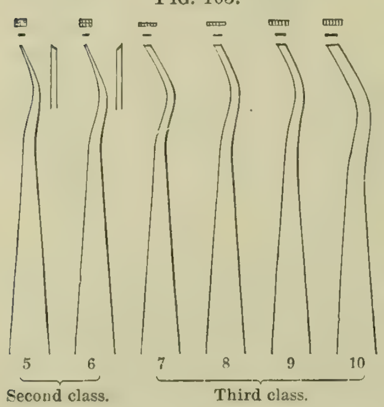
escaping by the proximate outlet. On account of these formations the filling is secured from escapement.

The filling of the cavity is best made in two parts, the first half to two-thirds being composed of non-cohesive gold and the remaining portion of cohesive gold. The former should be truly non-cohesive—in other words, incapable of becoming cohesive under the influence of heat. As previously described, gold of this quality is softer and more plastic, and hence is capable of being forced into the angle between the matrix and the margins of the enamel.

The second portion of the filling, being dovetailed in both directions, secures the non-cohesive in place, and it should be packed and condensed with care, for on it depends the security of the whole filling. The position of the line of union of the two kinds of gold is determined by the shape of the cavity, in some cases it not being necessary to have the second division greater than the thickness of the enamel. The pieces of non-cohesive gold are better introduced in the form of blocks or of flattened cylinders. The size should be adjusted to the cavity, in some instances each piece containing a half sheet. The cohesive gold may be formed into mats, or strips of No. 20 may be used. In each case the quality should be soft and extremely cohesive.

The best method of introduction is to take up the piece of gold in the pliers; direct the forward end of the block toward the junction of the matrix and enamel at one of the lateral walls, where it joins the cervical border; it should then be pressed into this joint with some energy, and with a suitable instrument the free end is forced into position. While it is held in place the other end of the gold is driven into the retaining-groove. The opposite corner is filled in the same manner. Next, the cervical wall is covered by forcing a block between the side next the pulp and the matrix. When these three pieces are fixed in position, they should be condensed, particular pains being taken to mallet the gold into the junction of matrix and enamel. To do this the filling-instrument should be of class second or third of Fig. 105. The principal effort at this stage should be to drive the blocks of gold into the line of junction of the margins and the matrix. The automatic plugger or Bonwill's mechanical mallet furnishes the best kind of force.

FIG. 105.



At this point it should be stated that when the matrix of this form is used and the gold is applied with proper instruments it will be wrought into closer apposition to the walls if the matrix is in close relation to those walls than when a space exists.

After the first layer is condensed repeated layers are made in the same manner until it is decided to commence the use of cohesive gold, when the last layer is not immediately condensed.

The first layer of cohesive gold is now incorporated into the last layer of non-cohesive by sharp single-line pluggers, and then the two are condensed together, after which the continued application and condensation of the remaining gold is conducted without much difficulty.

Attention must, however, be continued upon the marginal lines, and the fissures, which are sometimes continued outward from the retaining-grooves, should be followed out to their ends. The posterior fissure of the molars often forms an important element in the retention of fillings on distal surfaces, as its position adapts it to be opened as a continuation of the retaining-groove. When the operation is for a bicuspid, the enlargement of the sulci and some alteration of their form also greatly add to the retentive capacity of the cavity.

The matrix is removed by releasing the wedges, but in some cases the force of packing the gold drives the matrix into such close contact with the adjoining tooth as to render necessary the use of the pliers to withdraw this appliance.

When the matrix is taken away, the gold will usually be found in close proximity with the next tooth, as the force of packing tends further to separate the teeth. If it has not been provided for in the commencement by an ample space, it becomes necessary slightly to open to permit the finishing processes to be conducted, it being exceedingly important that the filling be not reduced in fulness.[1]

Inlaying Porcelain or Enamel and Gold.

This method of filling cavities consists in the insertion of a disk of tooth-enamel or of porcelain fitted to the form of the margins, but smaller to a degree sufficient to permit a fine line of gold to surround the inlaying and to connect it with the tooth. The purpose of the procedure is to avoid the unsightliness of large fillings in exposed surfaces; it is therefore principally adapted to the labial surfaces of the upper incisors and cuspids. There are also occasions when for fastidious persons this method becomes desirable in the mesial surface of the second bicuspid and first molar when the adjoining tooth is absent.

The labial cavities are prepared with circular margins, the sides being smoothly and truly shaped without undercuts and thoroughly polished. The floor of the cavity should be flat, if possible. In case the cavity should be round, a piece of steel should be loosely fitted to it, to allow room for the line of gold, and then hardened to full temper. On this cylinder a flat piece of porcelain is fastened by gum-shellac, which is done by fusing on the porcelain a bit of the resin when the cylinder is heated and pressed upon it. The disk can then by careful handling be trimmed on a corundum wheel until it will accurately fit the cavity. At the side which is to lie on the floor of the cavity the diameter of the disk should be exceedingly closely fitted to the sides. It is well also to polish the edge of the disk. The thickness of the disk should be sufficient to extend a half line beyond the surface of the tooth.

In case the form of the cavity be oval, the method of fitting the disk is necessarily different. When the preparation is complete, the interior

[1] For more extended details see *Dental Cosmos*, vol. xxvii. p. 194 *et seq.*

should be oiled and then wiped dry. An impression of the cavity and the face of the tooth is now taken with gutta-percha stopping. A cast from this impression is made, either of oxychloride of zinc or of phosphate of zinc, when the fitting of the disk becomes a mere matter of careful laboratory work.

The best substance of which to make these disks is a portion of one of the teeth manufactured by Ash & Sons of London, which are of fine texture and homogeneous throughout, and can be procured of sufficient variety of shades.

The preparation of cavities of the bicuspid and molar does not differ in the general features from that of the ordinary cavities of these teeth, except that there are no undercuttings or grooves at the lateral or the cervical walls.

In case the cavity be deep, the interior part is filled out, to leave room for the disk and to produce a flat floor. If the coronal wall is strong and occlusion of the opposing tooth can be prevented, it should be permitted to remain. If it be weak or broken away, the cutting here should be as heretofore described for gold fillings, and at each side slight retaining-grooves should be made to the depth of the enamel.

Insertion of the Disk.—Having keen vision and fine points, the insertion and securing of the disk become an easy task. For the front teeth a single layer of No. 20 or No. 30 should be laid along one edge of the cavity, including the end and side, and be allowed to extrude a little.

The disk is now inserted in the cavity and pressed to the bottom. The space is packed with narrow strips of No. 20, with plugger-points of extreme thinness prepared for the purpose. As the disk extrudes somewhat, the instrument bears against this, to protect the enamel, and, as both the disk and the enamel are polished, the gold is easily packed. After starting the gold at two points opposite the piece of foil first placed—narrow strips of No. 20—should be inserted and joined to this, which forces open the crevice to an even degree all around. This can be determined by the magnifying-glass. These preliminary steps in the packing are best made by hand-pressure; but when the arrangement of the first piece of foil is complete, it is better to use a light mallet and proceed with care.

When the fissure is completely filled, the projecting portion of the disk is ground away with corundum disks, smoothed with Arkansas stones, and polished in the usual way. In this manner inlaying of front teeth may be made, having a line of gold so thin as to be scarcely perceptible; and when well done, no method of filling teeth confers so great a sense of satisfaction.

The procedure of securing the disk and packing the gold is differently done in the bicuspid and molar teeth. When the coronal wall is absent, the disk should extend deeper into the cavity, and should not be permitted to occlude with the opposing tooth, but have some gold cover this portion; which part of the gold has its foundation in the two retaining-grooves spoken of above, or, haply, if a cavity exists in the centre of the crown, in this. The disk should have a retaining-notch cut along its edge at this point, into which the cohesive gold is to be forced.

The first piece of gold is composed of a thin block of No. 4, which is placed upon the cervical wall, against which is pressed the disk; and when its seat is secured, it is fixed by lateral attachments of gold, when the process of filling is as before described. Considerable care is required to pack the cervical border, and careful consolidation is necessary at the coronal aspect of the case.

When the case extends beyond the point of clear vision, or when the rubber dam cannot be forced high enough to reveal the margin, it would be allowable to make the cervical layer of tin and condense it by blows of an automatic instrument upon the upper edge of the guarded disk. As the importance of a fine line of gold is not so great here, the fissure may be larger than for front teeth.

We are indebted to Dr. Maynard for originating this method of filling labial cavities.

Finishing Fillings.

By the methods which have been herein described for packing gold, there should be but a small quantity of excess to be removed. If the gold be packed by layers of cut ribbon or of single thicknesses of heavy gold, the opportunity exists to produce nearly the correct form of surface.

Coronal Fillings.—To give these the proper concavity, finishing-burrs in the dental engine, followed by revolving burnishers and final polishing by pumice-stone carried upon revolving pieces of wood, which are supplied for the purpose, readily do all that is required. For removing considerable portions of gold suitable rotating corundum stones may be selected, which may be followed by the means previously alluded to.

Fig. 106.

Fig. 107.

Fig. 106 shows corrugated burnishers.

Fig. 107 shows Herbst's smooth burnishers, which are admirably adapted to coronal and buccal surfaces.

Labial and Buccal Cavities.—The form of the surface should conform to that of the teeth. If not rounded in their vertical direction, the bristles of the brush do not so thoroughly cleanse the margins. These should be very smoothly finished and left with a dull appearance, which may be given by a final rubbing with dry pumice, the wooden instrument being moved circularly over the surface, to avoid making regular lines of abrasion.

Proximate Cavities of the Front Teeth.—To facilitate the finishing process, these teeth should be kept apart or slightly more separated when it can be done, if the preliminary space be not sufficient. The form of these fillings should follow the line of the separation, and when the cavities are simple should be permitted to touch near the cutting edge and be kept apart toward the gum if this be possible. The line of gold which fills the countersink should scarcely be perceptible from the front view.

The palatal portion of the gold should be reduced to the face of the lingual plate of enamel and attention be given to the avoidance of con-

tact by the inferior teeth. The gold should then be somewhat rounded, to establish a slight separation of the labial enamel plates of the two contiguous teeth. The labial excess may be removed by fine files moved upward and downward, or may be planed away by fine, thin, square-edged chisels. The lingual excess is best cut away by small corundum points. When this is done, strips of fine emery-cloth, No. 0 and No.

Fig. 108.

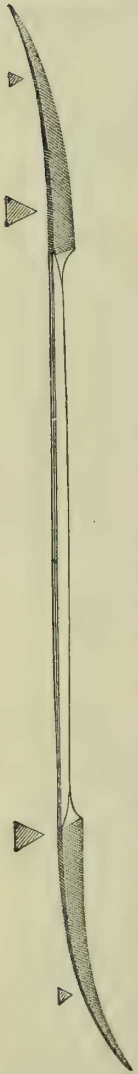


Fig. 109.

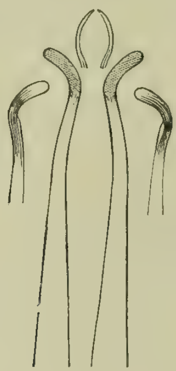


Fig. 110.

00, are used to cut down the excess to the correct shape. The surface is then finished by pumice-stone on linen tape.

An excellent plan to confine the powder to the tape and to facilitate its cutting is to mix it with glycerin. It is also improved in working qualities by adding to the paste a quantity of prepared chalk or of oxide of tin. This formula may be kept in quantity and used as occasion requires for various purposes.

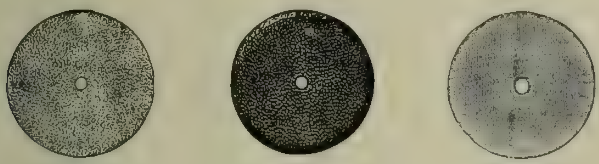
Between these stages of the process the gold should be burnished, but at the last be left without lustre.

Proximate Fillings of the Bicuspids and Molars.—In these the greatest care must be taken not to remove the gold which has been built out to make the contact-point. This has to be sedulously guarded. As the teeth have been separated by pressure and filled into contact, a Kaeber saw may be used to re-establish slight space. This saw may be so held as to cut down the face of the filling in a rounding manner, and also in such a direction as to open the space wider near the gum. As soon as this is done the outer and the inner excess should be removed—the inner, by corundum points; the outer, by files and chisels. After the bulk of the excess of gold is removed, for the finest finishing three forms of files have related uses, that of Fig. 108 being adapted to trimming the coronal surface at the line of its union with the proximate surface; that of Fig. 109, for rounding and smoothing the gold along the inner and outer margins; and Dr. Rhein's file (Fig. 110), for trimming the cervix deeply within the interstice. The remain-

der of the surface near the cervix may be trimmed by emery strips, care being taken to prevent them from cutting at the bulbous portion of the filling. It is often necessary, when the space is small, to introduce the strips of emery endwise, to avoid cutting the gold away at this point. The necessity for finishing beyond smoothness does not exist at the bulbous portion, since there is no tooth-substance adjacent thereto; but it is extremely important that a fine finish be given at the cervix, for the obvious reason that sedimentary substances may make a lodgment upon any unevenness of the gold or tooth.

When there is abundant space, disks of emery-paper and sand-paper are exceedingly valuable, but need careful guarding to limit their cutting to the proper places. Fig. 111 represents some of the various disks used

Fig. 111.



Emery. Sand. Cuttle-Fish.

for finishing proximate surfaces. Dr. Smith's annular disks, represented by Fig. 112, are intended to cut at the cervix of fillings, and may be applied in such a manner as to cut at any desired part.

The coronal portion of the filling should be finished in conformity with the occlusion of the teeth, care being had that the shock of the opposing teeth is prevented. This portion should be blended with the proximate part by natural curves. Finally, all the surfaces should be finely polished—first with coarse, and lastly with fine, powders.

Burnishing.—The burnishing of the surface of the gold is an important means of condensing the surface and of producing homogeneity. The burnishers not only effect this, but they temper the gold by increasing the hardness. The movement of these instruments should be from the middle portion toward the margins. This more effectively moulds the terminal edge into conformity with the outline of the margins. The forms of these points are too multitudinous to be introduced here. Various appliances are used to assist in the finishing process, such as coarse and fine burrs, corundum points of varied size and forms, and turned pieces of wood. These are all used by rotation in the dental engine.

Fig. 112.

Fig. 113.

Fig. 113 shows Dr. Perry's screw-head mandrel, which is an excellent adaptation for carrying all forms of thin disks. In it the disks are more quickly changed than in any other form in use.

Fig. 114 represents the Kaeber saw, previously alluded to.

Fig. 115 represents Dr. Bogue's tape-pliers for fastening the inner end of the tape used in polishing proximate fillings.

Fig. 116 represents Brown's metal tape for finishing between the teeth. These tapes have the important quality of being so thin as to enter spaces so small as to forbid the use of silk. They carry powders well, are of several widths, and of extreme service in polishing between the front

FIG. 116.

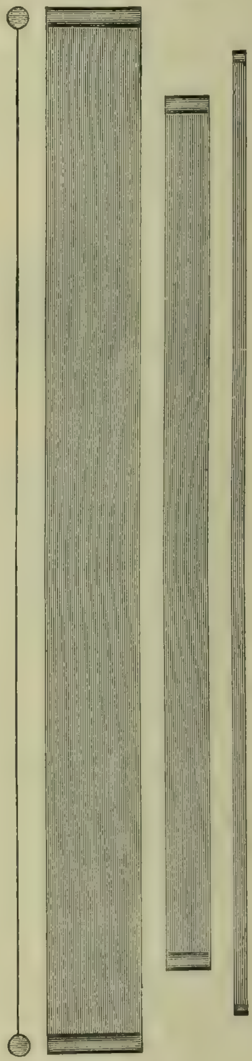


FIG. 115.

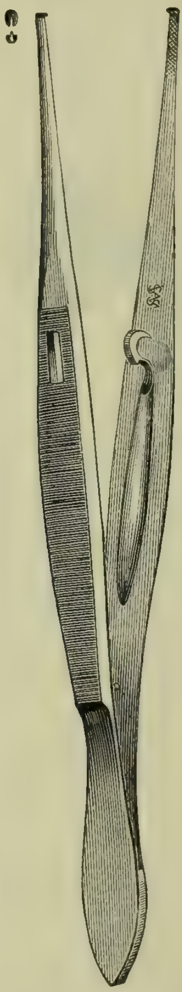
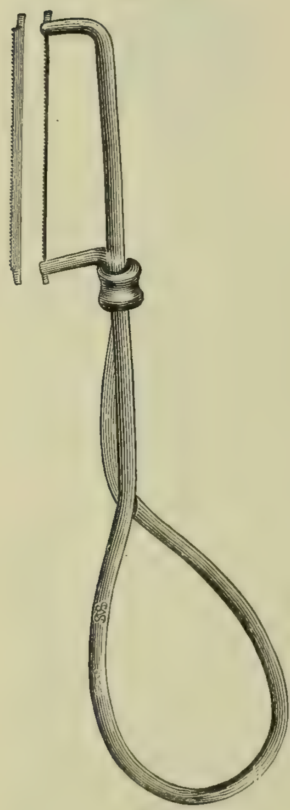


FIG. 114.



teeth with oxide of tin to give the surfaces a fine finish as a prophylactic measure.

In finishing proximate fillings care should be taken to avoid making abrasions of the gum-tissue, as often permanent disfiguration of the gum is produced by the careless cuts made by files, saws, and tapes used in trimming and finishing. The edge of the alveolus between the teeth may

be obliterated or be caused to be resorbed. When this occurs, the food is liable to find lodgment in the depression thus produced, and is often difficult of removal. After any unavoidable abrasions or cuts of this nature are made, even when slight, great comfort is afforded by dressing the wounded part with tincture of calendula, which should be diluted by the addition of two parts of water.

Deep-seated Caries.

Heretofore the consideration of this subject has been confined to the treatment of cavities of ordinary size and depth in which there has been no danger of involvement of the pulp.

It is assumed that the reader is familiar with the organic changes which occur in the dentine during the progress of caries, and which are elsewhere fully described. It has been shown that successive barriers of an undetermined character have been established in the tubules as the caries progresses, and that at length these are one after the other involved in the destructive process. It has also been demonstrated that the purpose of these zones of altered tissue is to preserve the pulp and its appendages from irritation. This functional activity enables correct treatment to protect the vitality of the pulp at even the last moment before the final encroachment of caries upon that organ.

When the cavity is deep, the greatest caution is requisite to avoid a needless uncovering of the dental pulp. The instruments should not be employed immediately over the threatened point, but should be engaged in lifting off the ultimate layers of caries at parts somewhat remote, leaving to the last moment the excavation over the cornua.

A question here arises whether great scrutiny should be exercised at the cornua to remove every part of the carious dentine, or whether the last portion should be permitted to remain, on account of the risks which attend the exposure of the pulp. The general practice is to leave a portion of the partially decomposed bone covering the pulp, to sterilize this, and to proceed with the filling. This method, it must be admitted, is the most judicious course in case the pulp be not actually encroached upon. The determination concerning this point, however, must be made after a careful examination of the question whether the pulp may not, after all, be really exposed ; for if so, it is more perilous to insert any kind of a filling, with whatever care and precautions, than completely to uncover and treat the case in agreement with the principles governing the management of full exposures.

There are a number of qualifying and guiding conditions which are to be taken into consideration, such as the age of the patient, the form of the teeth, the vital conditions of the patient, and the rapidity of the carious action.

When the patient is young, great caution is necessary, because the pulp has undergone less retrocession than is the case later in life. When the teeth are narrow at the neck and the cusps are acute, the pulp-cornua are correspondingly acute. When the vital conditions of the patient are high and the temperament is an active one, the qualifying

influences of this upon the retirement of the pulp are marked. When the progress of the destructive process is slow, the reparative power of the pulp is likely, if otherwise favored, to be active; but if, on the other hand, the caries has been active, the recuperative force of the pulp appears to be paralyzed, and this organ is quickly reached. All these conditions have to be weighed in forming an opinion of the probable nearness or remoteness of the central organ of the tooth.

When the pulp is nearly but not quite exposed,[1] irritation from thermal changes would probably follow should a metallic substance be placed in near proximity. There is even danger of this in some cases when the pulp may be at some distance from the filling. The manifest treatment under such circumstances is the employment of some non-conductor of heat immediately over the threatened part. There are a variety of ways and means laid down for this purpose. The safest single agent is a considerable layer of gutta-percha stopping. Another means equally efficient and better adapted to support an outside filling of gold is to fill the bulk of the cavity with one of the oxide-of-zinc cements. In this case the floor of the air-dried cavity should first be coated with a varnish of gutta-percha, to prevent the irritation which would ensue should the fluid element of the cement penetrate the thin layer of somewhat imperfect dentine.

In many cases this latter plan has the merit of imparting strength to the tooth. It is a necessary preliminary to dress the cavity with an antiseptic substance, as oil of cloves or carbolic acid, and in many instances it is also well previously to wash the cavity with dilute ammonia-water.

These precautions for protection of the pulp are more necessary in these days of solid metallic fillings than formerly, and therefore, in such teeth as the bicuspids—where, while the pulp is comparatively close to the surface, the cavity is not sufficiently deep to permit the above methods to be employed—some other course is necessary. For this purpose no substance is, on the whole, so well adapted as a disk formed from a piece of quill, which should be coated on one side with gutta-percha or mastic varnish. This has consistency, is hard enough to resist the force employed in packing gold, will yield and adapt itself to the cavity, and is a very imperfect conductor of heat. The disks may be formed in the same manner as will be described later for pulp-caps. In some instances it is admissible to use a complete temporary filling, bearing in mind, however, as has previously been stated, that the temporary filling should be of a metal with a comparatively low conducting power rather than a non-conductor, since the latter does not induce the organic changes desired. In this case the care above indicated should be taken at the point of nearest proximity of the pulp.

These precautions have been made in view of the frequent deaths of the pulp beneath fillings of the most excellent character—a result which, for obvious reasons, is more likely to occur to fine fillings than to inferior ones.

[1] For the methods of determining the probabilities of exposure the reader is referred to the next section of this paper.

Conservative Treatment of the Dental Pulp.

The question whether disturbances of the pulp arising as consequences of its exposure are amenable to recuperative treatment is a comparatively recent one, and is one concerning which there continues great diversity of opinion and much uncertainty of result. The paucity of literature on this subject would indicate either that the treatment is not generally satisfactorily pursued or that it does not rest on a scientific basis. There exists, however, abundant evidence that restoration to health of disturbed pulps, as indicated by long periods of quiescence and of complete recovery by deposits of secondary dentine, quite frequently takes place after judicious treatment. These well-established facts destroy the long-held adverse opinion that this result is an improbable one under any of the attendant conditions of full exposure.

The object of this section is the consideration of this subject in its clinical aspects.

For the minute anatomical structure of the pulp the reader is referred to other parts of this work. The salient general anatomical characteristics are—

1. The minuteness of the apical foramen of the completed tooth; 2. The ultimate nervous distribution beneath the odontoblastic layer, where a plexus is formed in communication with the stellate cells; 3. The arrangement of the capillary circulation in loops which spring from the vertical vessels and form congeries near the surface; 4. The absence of lymphatic vessels.

Certain important physiological qualities should be noted—viz.:

1. The deficiency of tactical sensibility; 2. The impatience of the pulp under compression.

The pathological tendencies after continued exposure, excluding the consequences of accidental compression, are—

1. To hyperæsthesia; 2. To circumscribed hyperæmia at first, and later to congestion; 3. To proliferation of the deeper-seated tissues as a consequence of latent congestion, such as the deposit of fatty cells, an increase of stellate cells of the fibrous tissue and of the development of nodular calcifications.

Each of these anatomical forms and physiological qualities has important bearing upon the pathological conditions and the field of practical treatment.

The exposure of the pulp by encroachment of caries is in three general ways.

It is encountered in the course of the treatment of ordinary cavities in a somewhat unexpected manner, no indications being given until the dragging or compression of the instruments awakens suspicion. Or we may be called upon to consider a variety of subjective indications, some of which, for want of intelligent definitions by the patient, may in many cases not be clearly made out.

Finally, there may be presented marked objective symptoms of the most unmistakable character.

Each case of encroachment upon the pulp, if it be permitted to run its course, may present the conditions accompanying all of these phases.

They are the measure of the degree of disturbance of the nervous and circulatory elements of the pulp.

The Evidences of Exposure.—The indications of this occurrence are all very various, depending upon constitutional susceptibility to nervous impressions. In some instances the pulp may be reached by the carious action; the encroachment may become an extensive one, and the carious matter may even be macerated and no marked unpleasant symptoms supervene. It is a remarkable feature of pulp-exposure that the encroachment of caries may have existed for many months without the least indication of the changed relations having taken place.

In some instances complete denudation and exposure to the atmosphere by the escape of the carious débris may occur without pain following. The pulp, by asthenic metamorphosis, may even become devitalized without the occurrence of a single pang.

The usual cause of an attack of pain appears to be the slight pressure of food or fluids into the cavity. This is shown by the difference of delay in disturbances of pulps exposed on proximate in comparison with those of coronal surfaces. Pressure in any form may at any moment bring on a decided train of symptoms, from the slightest to the most severe.

It is not difficult from these facts to deduce the general principle that the dental pulp in a state of health is not a very sensitive organ, and that it is not generally easily irritated by the ordinary substances and influences which exist in the mouth.

It must not be overlooked, however, that, on the other hand, there are those whose teeth are acutely sensitive to the earliest stages of encroachment by caries. It is fortunate for these that the manifestations demand early attention, and, as the cases are presented in the subjective period, the treatment is usually easily conducted.

Generally, in such cases, there is some uneasiness of the patient and solicitude for the tooth as soon as the pulp is reached. This may not amount to what may be called pain, but before long a series of manifestations commence, usually beginning with intolerance of cold substances. In some instances this may not be felt in the affected tooth, but may be attributed to some other one of the same jaw, or possibly of the other row of teeth.

It should be noted here that intolerance of cold is one of the earliest indications of a disturbed pulp, the whole body of the tooth often appearing alarmingly sensitive to impressions made by cold applications.

This impressibility of the tooth by cold is a peculiar condition. The seat of the sensation appears to be peripheral; it pertains to all surfaces of the tooth; and if the cavity be closed with a non-conductor, it is felt as acutely as before. Up to certain limits it persists as long as the irritation continues, and increases or declines in accordance with the degree of central irritation with so much uniformity that it may be taken as an index of the intensity of the disturbance. This sensation is to be differentiated from that of acute sensitiveness to cold occurring in incipient caries, the seat of sensibility in this case being the carious surface, the sensation ceasing when the cavity is protected by a non-conductive stopping.

In the former case, as stated, it is as if the reticulum beneath the enamel were impressed, but the sensation is probably due to a hyperæsthetic state of the nerves of the pulp itself, and is in agreement with the general principle that disturbed nervous filaments are irritated by cold and relieved by heat.

There next arises a sense of undefined uneasiness in the other teeth, felt only at intervals of several days and recurring without regularity. A sense of vacuity in one of the other teeth, probably remote from the affected one, may be experienced, the patient insisting that a filling has become displaced. There may be flashes of pain in the ear, in any or all of the teeth of the side affected, in the inferior orbital region, in the lower lip, or in the sterno-mastoid region. As the irritation is longer continued these evidences become more decided. There is greater sensibility to cold, the reflected pain increases, coming on in the evening, and may recur on successive evenings. In some cases the pain extends to the nerves supplying the nasal membranes, in which the illusion of thickening of the Schneiderian is produced.

As these symptoms become marked there may arise exaltation of sensibility to heat when it is applied to the teeth, and yet the patient may not be able to locate the pain in any individual tooth. Shortly after this phase of the case arises some soreness is manifested upon the application of pressure to the affected tooth. There is at this stage some determination of blood to the pulp instead of a previous hyperæmic condition of a portion of it, and as, from the smallness of the foramen, the admission of blood is restricted, it is distributed upon the peridental membrane. The column of blood, while not being admitted, may also produce some pressure of the nerve-fibres. As the tendency to congestion advances there arises a feeling of pressure within the tooth; at the same time an aggravation of all the other symptoms becomes apparent in consequence of the compression of the nervous filaments.

During the progress of the case these symptoms, as they develop, may not daily recur until toward the last, and generally are felt only in the evening or in the night. Sometimes the patient awakens at night out of sound sleep, may be kept awake an hour or more, and may sleep the remainder of the night. At length the subjective symptoms become more masked by the increasing character of the objective ones; the sensitivenesss to heat increases; that to cold diminishes; the peridental soreness is exalted; torturing pulsative throbs of pain set in, which end, if no relief is afforded, in the early death of the pulp by stasis.

Pain of the character stated occurring at night is, even when slight in degree, one of the most characteristic evidences of irritation of the pulp; so that the question whether the patient has had pain in the evening or at night is of the utmost importance in making the diagnosis. Usually, when the seat of the disturbance of the pulp is not easily determined, the application of a cold substance will reveal it. If there is any difficulty in determining the affected tooth, the isolation of one after the other of the possible teeth by means of a piece of rubber dam passed over them in succession, an application of cold being made to each in turn, will usually be sufficient.

The application of cold in this manner becomes an important method

of differentiation in attacks of neuralgia dependent upon gout or malaria.

The neuralgic attacks of the terminals of the trigeminus are so similar to the reflected pain of the early stages of pulp-irritation that it may be difficult to make a correct diagnosis. The absence of sensitiveness to cold and the occurrence of paroxysms in the earlier hours of the day are usually conclusive.

The pulp, when exposed by caries, and even when in a state of some irritation, may by a light hand be touched with a minute point without the patient being cognizant of it; but if the touch is accompanied by the least pressure, the pain is intense.

This, coupled with the other fact that the pulp may for many months be in contact with devitalized matter without disturbance, goes to prove that the pulp is not in all cases sensitive to the mere presence of foreign substances, and supports the view that the dental pulp is deficient in tactical sensibility. Further, the fact is well developed that in the majority of instances the opportunity exists for more or less decided chemical influence to be excited, since the softened bone in contact with the pulp is capable of osmotic transmissions of the varying fluids of the mouth, and of being at least partially saturated by the fluid ingesta. The sum of these facts would indicate that, as regards the success of treatment, there is a more than reasonable ground for a hopeful prognosis.

It will be easily recognized that the stages of pulp-exposure are divided into three periods—one of quiescence, one of subjective symptoms, one of objective manifestations.

Cause of the Subjective Disturbances.—The questions naturally arise, What is the origin of the subjective symptoms? Are they the result of increased supply of blood to the part brought on by the changed relations, or are they caused by the impingements upon the pulp of fluids and other substances forced against it?

It has been shown that, in many instances the latter must be a principal factor in the production of these symptoms. Indeed, it may be regarded as an axiom in the treatment of the pulp *that compression is the most serious condition to which it can be subjected.* All means for the relief of pain and all measures of treatment must always have this fact in view.

The questions above proposed are not capable of an easy hypothetical solution. Pressure as a cause is always immanent, and, while an increased blood-supply, as has been shown, is not a decidedly active factor, there are instances in which it appears to be alone sufficient. When, however, this is the case, the consequent disturbances are probably the result of compression by the force of the blood-column of the nervous elements of the pulp within the bony cell.

Examinations of pulps which have been exposed and subject to irritation to such a degree as to induce their extraction do not usually present the appearance of the state of engorgement of blood which would naturally be expected. On the contrary, the increased vascularity in many instances is limited to the immediate point exposed to irritation. This is in agreement with the phenomenon of simple irritation of the pulp, which passes away as soon as the part is released

from pressure and chemical irritation, and is explained by the peculiar anatomical arrangement of the capillaries of the surface of the pulp, it being in distinct loops arising from the larger vessels.

The result would be different if the arrangement of the capillaries were in an anastomosing plane. The irritation in this case would lead to diffuse disturbance, as happens in the serous membranes. Thus the altered relations of the pleura and of the peritoneum by their exposure to the atmosphere and the consequent septic influences quickly induce diffuse inflammation of these structures. The tendency, therefore, of the organization of the pulp is toward the limitation of the zone of disturbance to the point of impingement of the irritant.

Heider also supports the same view when he states: "Inflammation does not appear to be present, for the accessions of intense pain occur without any warning, and even with great intensity, but frequently, however, intervals occur during which there is entire freedom from pain. Cold applications which diminish the pain induced by inflammation increase them in this case."

From the appearance of the surface of the exposed pulp, from the lack of continuity of the symptoms and the various expressions at different times, it may be reasonably inferred that the hyperæsthesia observed in these cases is due to some impression near the point of irritation which excites the nerve-fibrils distributed to the capillary loops involved, and thereby induces the reflected phenomèna observed, the nerve-fibrils being in this stage the anatomical element chiefly implicated.

Cause of the Objective Disturbances.—The occurrence of objective symptoms is more easily accounted for, as they are the result of continued irritation and may assume alarming proportions. They comprise those manifestations which, after the subjective ones have been in existence for some time, become localized in and about the affected tooth. These are sensitiveness to heat, some soreness of the peridental membrane, heavy and pressing pain in the tooth, and at length throbbing as congestion becomes established. This relation is the usual sequential order of occurrence of the objective symptoms when the conditions are progressive—that is, when they are the expression of continued chemical or septic influences. When they are produced by the impact of food or as the result of accident, the expression may be without sequence.

The causes of those phenomena which result from the decided compression of the pulp have not clearly been made out. It is not difficult to estimate the immediate effect of direct pressure upon the pulp when in a hyperæsthetic condition, situated as it is in a cell of fixed hard boundaries, but the results extend beyond this, and the impression made by a single pronounced compression continues and is liable to be fatal to the organ. The reason for this may be looked for in the dislocation of the pulp from its connection with the dentine at some point which may be remote from the orifice of exposure. The feebleness of the connection of the pulp with its walls renders such an accident one of easy occurrence. This changed relation, it is easy to perceive, may be a new cause of irritation, which, supervening upon its other conditions, would render recuperation questionable.

In illustration of this, a capped pulp of the writer which had remained for several years in an entirely comfortable condition was opened for the purpose of renewing the temporary filling, when the operator made considerable pressure upon a piece of cotton. The pain from this was very severe, and, although the pulp was carefully recapped at that sitting, reflected pain set in, which at length became, after many days of careful treatment, of an objective character. These two sets of conditions acted and reacted back and forth upon each other until it became necessary to remove the dressing and devitalize the pulp.

In some instances, as before noted, the occurrence of these more pronounced evidences of disturbance may be simply the manifestations of sensitive constitutional organization at an early stage of the exposure, or they may be a reflex sympathetic expression of some disordered function of remote organs.

The evidences of considerable diffusion of the hyperæmia is marked, since the tooth becomes sensitive to heat, while the application of cold is less irritating, and at length is soothing. The subsidence of the irritation by cold is a clear indication that for the first time in the case the determination of blood has become a marked peculiarity: a new phase of the case has been entered on. The pain soon becomes continuous, all the local manifestations increase, and at length overcome and completely mask the subjective symptoms.

If the condition causing these symptoms be permitted to continue, the access to the pulp of an additional supply of blood necessarily brings about tissue-changes, the sheaths of the arteries and veins becoming lax and indistinct. The capillaries, in agreement with the usual result of enlarged capillaries in tissues which are not firm or elastic, lose their power to assume their natural dimensions. Changes also take place in the neurilemma of the nerves and the centres of the nerve-fibrils become irregular and enlarged. Changes also occur in the connective tissue, whereby marked proliferation of cells of irregular form takes place; protoplasmic deposits occur and frequent disorganization of blood-corpuscles happens. These pathological changes offer serious embarrassments to treatment, the force of which will appear in the sequel.

With this summary of the phenomena attending exposure and of the apparent condition of the pulp in its three stages of disturbance, preparation is made for consideration of the practical treatment of the exposed pulp.

The earlier attempts in this direction included the medication of the organ with tannic acid and creasote or similar substances, after which it was arched over by some form of cap, the simple object of which was to preserve the pulp from pressure during the introduction of the protective filling. The results were unsatisfactory in nearly every instance. The cap accomplished the object aimed at; it also provided a film of air to act as a non-conductor of heat; but very soon pain of severe character would arise, with marked objective symptoms.

It is not difficult, in the present state of knowledge on this subject, to understand why this procedure fell into disuse. The disturbances were due to pressure caused by the gaseous results of the decomposition

of the fluids effused into the vacant space. As soon as the filling would be removed the pain became less, but another attempt would be followed by the same results. For these reasons the operation of capping the pulp was generally abandoned.

What at length became indicated as a correct line of treatment was some manner of covering which would completely fill the space around the point of exposure, and thus prevent the existence of a receptacle in which effused serum or lymph could accumulate. This method of treatment was devised by Dr. Keep, who employed a paste of oxychloride of zinc laid over the exposed pulp. The introduction of this method gave a new impulse, and out of this practice has grown more careful attention to this important subject, until we have approached the beginning of a rational system.

The procedure when oxychloride of zinc is employed is completely to denude the pulp of its carious covering, and after dressing the surface freely with pure carbolic acid a covering of a paste composed of the oxide in a solution of zinc chloride is placed over the point of exposure. After this has become sufficiently hard the remainder of the cavity is filled with some temporary filling the packing of which will not break up the integrity of the capping. The operation is attended with considerable pain, occasioned by the irritating action of the zinc chloride upon the sensitive surface of the pulp. In some instances the pulp becomes comfortable, but in very many the results are far from satisfactory, since, after a varying period, the pulp is found to be devitalized.

The application of zinc chloride in this form and manner is of extremely questionable propriety, for the reason that on account of its excessive affinity for water it acts with decision upon the pulp before it has effected its combination with the oxide. It combines with the albuminous elements of the tissue, and so far deprives a portion of the pulp of vitality. This affinity of the zinc chloride for water also induces the sphere of its irritation to be extended to the deeper tissues of the organ.

A remarkable phenomenon of the action of chloride of zinc upon the pulp is that in some it produces a coagulum of marked toughness, which for a considerable period retains its connection with the living portion beneath it.

A modification of this method practised by some is to use a weak solution of the zinc chloride and manipulate the paste until near the point of hardening, when it is laid upon the pulp and carefully spread out. This modification avoids the excessive strength of the fluid menstruum, and also permits the neutralization of nearly all of the chloride. In short, the chemical power of the paste to act on the pulp is diminished. This method, however, is liable to occasion compression and therefore seriously jeopardizes success.

The most rational mode of treatment, which in various forms has received wide acceptance, is that introduced by Dr. King of Pittsburg, which consists in covering the exposed pulp with a paste composed of oxide of zinc and creasote or carbolic acid. This is flowed over or carefully laid on the pulp. This in turn is covered with a layer of oxychloride of zinc, and the remainder of the cavity is temporarily filled

with any suitable material, or the whole of the cavity is filled with this substance, which is permitted to remain for a variable period, depending upon the condition of the tooth and the character of the filling as ascertained by subsequent examinations of its condition. The essential features of Dr. King's procedure consist of the chemical and therapeutic action of the carbolic acid, of the complete adaptation of the covering laid upon the pulp, and of the entire avoidance of pressure. Upon conformity to these three principles depend any chances of success, and it may reasonably be stated that only as any method includes these principles of treatment can there be a promise of good results.

The most reliable method of protecting pulps in agreement with Dr. King's method is as follows: When it is determined by the symptoms or by direct examination that the pulp is fully exposed, it is completely denuded of the carious matter covering it. At the same time the remainder of the cavity should be so carefully prepared that it may be filled temporarily in a thorough manner to prevent carious action recurring at the margins of the filling. The pulp should then be dried and have an application of pure carbolic acid made to it for a moment only; this produces a superficial coagulation of the surface of the pulp. It is now covered with a convave cap of platinum filled with a paste composed of oxide of zinc and equal parts of carbolic acid and oil of cloves. After a moment the cavity may be filled with any of the plastic materials, and in some to be hereinafter described it may be permanently filled in any manner whatever. This plan of treatment is founded on the hypothesis that if the pulp will bear contact with carious dentine and the consequent chemical and septic influences it should endure the presence of a non-irritating substance which excludes these deleterious influences.

Various other similar methods of capping have from time to time been devised, such as disks of medicated paper, of goose-quills, and of gutta-percha, which, however well adapted in some respects, are deficient in the essential particular that they are not in absolute contact with the surface of the pulp, and cannot be inserted without liability of producing compression.

This summary of treatment requires more extended elucidation. In order to present the subject as clearly as it may be done, it should be divided into three parts:

a. The treatment when the symptoms are subjective;

b. The treatment when the symptoms are objective;

c. The treatment when the exposures are traumatic.

a. Treatment of Conditions when the Symptoms are Subjective.—It should be kept in view that usually when the symptoms are subjective the pulp remains covered by carious matter of considerable consistency, the circulating elements being but little excited—that it is simply in a hyperæmic state, but, in consequence of the changed relations, its nervous elements are functionally somewhat disordered. The various expressions of this have been previously detailed.

In order to have complete command of the case it is advantageous to envelop the affected tooth in india-rubber. When, however, the cavity is an accessible one, this need not be done until the bulk of the caries

has been removed, as it is more convenient to wash away the débris before the dam is placed. But when the approach is made to the pulp, it is necessary to have exclusion of moisture, to enable a full view to be had, that the instruments may be used with precision to avoid wounding the pulp and without making any pressure upon it by any incautious movement, as, when the cavity is wet, on account of the refraction of light, miscalculations of direction and depth are easily made even during the most careful manipulation. It becomes necessary to remove all the carious matter, because its presence is unnecessary and prevents the action of the medicaments. Formerly it was considered better to leave a last layer of decay, on the ground that this should be more agreeable to the pulp than any foreign substance whatever, but this practice has not proven to be successful. It ignores the requirements of and the necessities for therapeutic treatment, and experience has proven that other coverings are more acceptable to the pulp than the ultimate layer of decay. In this field no form of theorizing should be entertained as of any value which is not supported by a system of treatment which has been followed by successful results.

But little therapeutic treatment appears to be required; but if the pulp in this condition be simply covered by an inert substance, failure, for reasons which do not very clearly appear, quickly follows the attempt.

The therapeusis indicated is that which will destroy whatever septic influence may be present, and which will without irritation to the pulp impair the vitality of the exposed surface to a very superficial degree. These conditions are best met by the cauterization of the point with pure carbolic acid.

There is an easily-recognized similarity in the action of carbolic acid and chloride of zinc upon the tissues of the pulp. Both have considerable cauterizing power. There are, however, very important differences in their action which favor the selection of the former for the purpose in preference to the latter. The action of carbolic acid is less pronounced and more superficial, whereas the tendency of chloride of zinc is to the production of a deeper impression, because its affinity for water is even more marked than its capacity to coagulate albûmen. As carbolic acid has but feeble affinity for water, its action is limited to the surface, which is the effect desired. When the tent of cotton conveying the medicament is removed, the action is terminated. Not so is the result with chloride of zinc, as, on account of its attraction for water, a portion may be imbibed by the pulp, this being liable to irritate the whole mass of the tissue.

In this connection it should be stated that the pulp is impatient of medication, whether of irritating soluble substances or of anodynes which are not perfectly soluble in its fluids. It is probably for this reason that such drugs as opium, morphia, tannin, etc. exercise a deleterious influence upon the pulp and fail to manifest the physiological effects they exert on other tissues. The absence of lymphatics is explanatory of this intolerance of the pulp. Even aconite has less power to relieve an attack of odontalgia when applied to the pulp than when the application is made to the gum.

The question has arisen whether carbolic acid in purity may not be more irritating than a dilute solution of it. A slight examination of this subject would quickly indicate that the pure form is less irritating and more efficient than the dilute. It must be borne in mind that neither of the results aimed at can be effected by a dilute solution, and that its irritating influence is reduced to a minimum by its concentration, because on making contact it so completely and immediately coagulates the superficial portion that its action is limited to the superfices. Because of its weak affinity for water it is not taken up by the vessels of the pulp, and therefore there is no apparent irritation. When, on the contrary, a ten- or twenty-per-cent. solution is used, coagulation is not effected and the pulp is liable to imbibe the solution. This is more particularly the case if the menstruum be alcohol or glycerin, because of the strong affinity both these substances have for the watery elements of the pulp.

The paste generally used is composed as heretofore stated. The therapeutic reasons for this do not appear to be clear, and require further experimentation. The combination of these somewhat similar agents with oxide of zinc produces a paste having the necessary mechanical conditions of softness and plasticity, and, at the same time, a degree of consistency which enables it to remain in the cap, which is an important consideration, as will appear. Sometimes, after several years, the contents of the cap will be found to be so hard as sensibly to resist the application of instruments. The oil of cloves appears to be an almost indispensable ingredient, which is probably due to its anæsthetic and antiseptic properties. The probabilities are that the anæsthetic action of the oil of cloves is prolonged upon the pulp until sufficient time elapses to secure the equilibrium of the anatomical elements.

In many instances of this class of cases other equally successful means of filling the cap may be applicable. When it is considered that the pulp is tolerant of some kinds of irritation without disturbance, it does not appear that the choice of the materials composing the paste need be limited, so long as it possesses plasticity and the capacity to prevent septic action for a short period.

The covering of the pulp by the cap in accessible positions, such as the mesial proximates and coronal cavities, is a simple procedure. It is inserted edgewise, one edge placed in contact with the floor of the cavity, near the point of the pulp, and laid over the exposure, in order to avoid direct pressure either by forcing air before the cap or by forcing some of its contents against the pulp. If laid in this manner, the excess flows out at the margin as the cap is pressed down upon the circumjacent dentine.

Should the pulp be exposed in a deep depression, as is sometimes the case, or should a portion of the pulp be sloughed away, as may without previously manifested disturbance occasionally happen, the depression should be filled with a portion of the paste by means of an instrument armed with some of it; otherwise, there is danger of leaving a space not completely filled with the paste. The importance of the closure of the least space is so great that the utmost care in this respect is necessary.

Mode of Forming Caps.—The material, when of tin, should be rolled to the thickness of No. 28 gauge; when of platinum, of No. 30. The disks may then be punched out of the sheets of metal upon the end-fibres of a hard block of wood or upon a block of tin by means of leather-punches, of which both round and oval ones can be procured of hardware-dealers. The act of punching them produces the necessary degree of concavity. The caps usually supplied by the dealers are too large and too much arched for general uses. It is obvious that to prevent forcing the paste upon the pulp the cap should not be punctured, as has sometimes been done.

After the covering is complete the filling of the cavity is to be made in such a manner as may not break down the cap, and thus make pressure of its contents upon the pulp.

Whether the filling is to be a temporary or a permanent one depends upon a great many considerations.

If the pulp has been encountered in the course of the preparation of the cavity and no history of the least disturbance can be elicited, and the physical character of the patient is favorable, the tooth may be permanently filled, in which case, it is obvious, the cap should be of a resisting material, as of gold or platinum. It is also obvious that the introduction of the filling material must be in such a manner as may not displace the cap. After the cap has been in place for a few moments, and any excess of the paste which may have been forced out at the edges is removed, a block of gold somewhat thicker than usual and of such size as to extend considerably beyond the cap is laid flatly over it. While the block is held in place the gold is adapted to the surface of the tooth about the cap. Other blocks of gold are next placed in the cavity, to form the foundation of the filling, which is done in the usual manner. Or cohesive gold may be established in the pits and retaining-grooves, and the gold, as it reaches the block, will fix it in place. The block is continuously treated as the bottom of the cavity and every care taken to prevent its displacement. The fixation of the cap may easily be effected with any of the formulas of amalgam where the stopping is made of this material.

When, on the other hand, there have been continued subjective indications of exposure, the filling should be a temporary one. The choice of materials for this purpose unfortunately is limited, as they are generally unsatisfactory. As it is necessary in most instances, if the pulp becomes tolerant of the treatment, that the filling be permitted to remain for several years, it is important that it be one which will well preserve the tooth and itself undergo no changes. On the whole, there are only two which fulfil these conditions—viz. gutta-percha and amalgam. The former possesses two disqualifications: where exposed to direct force of mastication, it loses substance by friction, and, as it becomes reduced in bulk, the elasticity of the material at length permits pressure upon the pulp unless the cap is of platinum. In respect of the latter substance, while it is admissible in cases of very trifling disturbance, in the graver lesions it is not allowable, on account of the thermal influences its presence may induce. As allusion has been made to the use of metallic fillings, it is a pertinent consideration that, as the immediate neighborhood

of the pulp is protected from the influence of thermal changes, the presence of a metallic substance in the cavity may exert a beneficial influence upon the recuperation of the pulp by inducing reparative efforts at the treated point. Careful discrimination is required to be made not only as to the admissibility of this course, but as to the choice of materials. Generally tin and amalgam, because of their low conductivity of heat, are the substances best adapted.

Of temporary filling materials, the one least reliable is phosphate of zinc, on account of its extreme liability to lose substance near the gum-line. From this cause renewed disturbance of the pulp may quickly arise. It is, however, adapted as a filling for coronal cavities, where this danger is least, and where it can easily be inspected.

It is an important consideration in the conservative treatment of exposed pulps that they be placed under immediate protection, as, if treatment is delayed, they are liable to incur serious risks of dangerous irritation.

Treatment when the Symptoms are Objective.—The line of demarkation of this class of cases does not at their first presentation appear to be easily made out. The differentiation is confusing, because the subjective symptoms persist after the objective ones set in. The former may even become exaggerated for a short period, because the greater determination of blood to the pulp increases the excitement of the nervous fibrillæ, and therefore the indicative symptoms of increased blood-supply may be overlooked. Before actual pain is localized at the tooth there are evidences of increased determination of blood, which is indicated by the tooth becoming responsive to applications of heat, and by the fact that the tooth, when pressed upon or when struck, gives evidence of some uneasiness at the apex of the root. An examination of teeth extracted in this stage will often show more disturbance of blood-circulation at the apex of the root than of the pulp itself.

These simple objective conditions may be completely masked by the assemblage of subjective symptoms. When obscured, they frequently become the most serious and intractable of disturbances. When they occur early in the history of any given case or arise out of a previously-treated one, they demand immediate and energetic attention.

The range of objective disturbance, from the first recognizable increase of blood-supply to that height which has its culmination in the death of the pulp by continued stasis or by strangulation at the apical foramen, is very great, and the cases of different persons present very wide variations of excitement; whereas in the class of cases first considered all the indications of disturbance point to an increase of nervous sensibility of the pulp which may intensify in degree to extreme hyperæsthesia.

In the class now under consideration the circulatory elements of the pulp become excited. At first there is hyperæmia, not only at the point of exposure, but of a considerable portion of the pulp, with other evidences of enlargement of the vessels. The peridontium also quickly becomes involved, although this is not at first easily recognized. As the determination of blood to this membrane becomes noticeable there may be an increase of the neuralgic disturbance consequent upon the excitation of the peridental filaments, as well as by their impingement between the

tooth and the process. These conditions occasionally become established previous to complete denudation of the pulp, but generally they are not pronounced until this period approaches, or even has supervened. As the caries advances and the pulp becomes completely denuded of the covering of carious matter, certain marked changes usually take place at the superficial portion of the structure, in addition to the proliferations of tissue which may have already occurred in its deeper portions.

Effusion of Serum.—At first serous discharges form on the surface which are akin to the effusion common in all slight or subacute inflammations of serous and areolar tissues.

A tendency to this condition does not appear to exist in stages of exposure previous to that of direct contact with the atmosphere, the amount of general hyperæmia being not then sufficient to induce this condition. It will, however, be nearly always observed, in some degree, after the exposure to the atmospheric influence becomes complete.

Effusion of Lymph.—Again, slight discharges of lymph may take place, and this must be considered a salutary condition. Were the situation such that this film of plastic matter could be protected from the changes caused by septic influences, it is not unlikely that it would in some cases of slight modification of the sound pulp-tissue be utilized in reparative processes. The situation in the mouth and in the carious cavity places this out of the question. The embarrassment of the treatment in this direction is considerable, since it is necessary to protect the parts from disturbance; and to do this efficiently involves a liability to press back the effused fluid upon the sensitive organ from which it arises.

Formation of Pus.—As the case advances the lymph becomes markedly corpuscular and an ulcer at the point exposed to the direct excitation is developed, and pus is discharged, this being accompanied by gradual loss of tissue. In some instances this process of ulceration continues until nearly the whole of the pulp is disintegrated in this manner, and it may even progress until the ulcerating point is found at the apex of the fang, upon the peridental membrane.

These three forms of effusion have each considerable significance. They are indicative of the condition of the blood-vessels of the organ, of the changes which have taken place in the structures of the pulp, and of the constitutional tendencies of the patient. The general laws of pathology must have here similar expressions as elsewhere, and the character of the products bear the same relations to the stages of the inflammatory process they elsewhere do.

There is, however, one modifying circumstance which may have considerable influence in determining variations in the conditions presented; this is the limit which is placed upon the return of the blood caused by the minuteness of the foramina at the points of the fangs. This qualification, it would not unreasonably appear, should increase the tendency to effusion of serum, since the calibre of the return-current necessarily is restricted.

Not only does the state of the circulation of the pulp modify these conditions, but the physical characteristics of the patient are of the utmost importance. This consideration is important not only in the

advanced and serious cases, but also in the simpler ones, which have already been discussed, where the pulp is at most superficially affected by a hyperæmic state. If the patient be of healthy and vigorous constitution, the tendency will be toward reparative action; but if, on the other hand, the individual be cachectic or in a state of impaired health, the inclination of any local disturbance is toward corpuscular and aplastic conditions and tends to the degeneration of effused secretions.

As the final result of the treatment of the pulp is the restoration of the former relation of parts, by which this organ is again protected by its normal covering, it must be kept in view that this can be accomplished only by the organization of effused plastic elements or by histological changes in the organized structures of the pulp subjacent to the eschar. In the former case a variety of circumstances tend to qualify the result. Of healthy constitutions, when correct local conditions are established, the tendency of plastic lymph in all the tissues is upward toward normal organization. In the pulp it should tend to the creation of fibro-cellular material. This development is liable to arrest by an unfavorable state of the patient's health or the continuance of a congested condition of the pulp. It is scarcely necessary to do more than call attention to the well-established pathological principle that states of congestion and of inflammatory disturbance are unfavorable to plastic reparation. It will now easily be recognized that all efforts should be directed to reduce irritation and restore equilibrium of the circulation.

In cases where there have been continued objective evidences of disturbance it is next to useless to make attempts for the preservation of the pulp. In the great majority of such instances these attempts, in the hands of the most careful experts, have proven disastrous, and when persisted in may jeopardize the best results after the extirpation of the organ. The treatment of exposed pulps of this character does not present any encouragement if they have passed beyond the period of responsiveness to cold applications.

The Practical Treatment of this Class of Cases.—It is obvious that if any effort be made to treat by capping the pulp in the previously detailed condition some preparatory treatment is necessitated. Any attempt to cover up a pulp in an unhealthy state would be almost immediately followed by disturbance. It will be recognized that, however near normal the effused fluids may be, covering the pulp will not check their formation, and, as they cannot make their escape, a direct result will be compression. If pus has commenced to form by the degeneration of the lymph, the conditions are still more serious, and a complete change must be produced in the state of the suppurating surface.

At the very commencement of the manipulative treatment the pulp should be completely uncovered and carefully dried and examined. If no effusion has taken place, it should be depleted by a careful and quickly-made incision. In many instances the patient will not tolerate this without the use of either a local or a general anæsthetic. Whatever pain remains after the bleeding has subsided may be relieved by the application of oil of cloves in equal combination with chloro-

form. The peculiar arrangement of the vessels of the pulp does not favor the free escape of blood from the vessels, for as soon as the loops directly involved are depleted the bleeding ceases. But, however slight the loss of blood, the benefit is marked. After comfort is secured the case should be capped with a very thin paste, as previously described, and the cavity filled loosely with pellets of cotton partially saturated with sandarac varnish. The excess of the solution of sandarac should be well squeezed out of the cotton, to prevent the complete sealing of the cavity, and yet should be sufficiently filled with the resin to prevent the fluids of the mouth from entering. This filling may remain for several days, when, if the symptoms cease to be of an objective character, an attempt may be made to protect the pulp, in agreement with the procedures previously described.

Aconite and chloroform should be applied to the gum at the time of application of the cotton filling, and should be repeated at intervals of two days.

Treatment if Effusion of Serum or Lymph Occurs.—The treatment in this condition should commence with the application of aconite to the pulp and also to the gum, followed by the coagulation of the pulp-surface by carbolic acid. If, after the drying of the pulp-surface, no further fluid is found to exude, the closure of the case may be made immediately or remotely, according to the character of the other indications. If it becomes necessary to delay the case, a cap filled with a paste of oxide of zinc and water should be laid over the pulp. This paste does not become hard by evaporation or by combination of its elements, and will permit any effused fluids to pass through it, and yet it will furnish protection from external irritation. In this connection it should be stated that oxide of zinc pure and simple probably possesses some therapeutic power, as its properties are astringent, and it also is regarded as a nervous tonic.

The cavity should now be filled with pellets of sandarac and cotton as before described. The density of this temporary dressing should be such that the fluids of the mouth may be excluded, and yet so loose that any further effusion from the pulp may enter the interstices of the lint. If after several days of protection in this manner and of the action of aconite the symptoms, including a diminution of the thermal disturbance on application of cold, have passed away, the case may be opened and treated as previously described. Should, however, the amelioration of the symptoms not take place, the reasonable inference may be formed that the general tissues of the pulp are too much disordered, when the proper course will be the extirpation of the organ.

It will be observed that the necessity of depletion appears less in cases where effusion takes place than where the surface of the pulp shows no indication of this. This difference is borne out by observation, and has no other apparent pathological ground than that congested parts or surfaces arrest the production of lymph. It is also observed that the pain is less in cases of effusion than in similar ones when there is no production of lymph, for the obvious reason that the pulp finds relief to the engorgement of its vessels by the escaping fluid.

Purulent Discharges from the Pulp.—An application of the simplest

principles of medicine renders questionable the conservation of pulps in a purulent condition when evidences exist that it has been of long standing. There are, however, exceptional cases of recovery of healthy conditions even after some loss of tissue by sloughing of exposed cornua.

It is at once apparant that radical measures must be adopted to effect an entire change not only in the secretions of the surface, but of the structure of the superficial part. The tendency, when suppuration has become established, is to a continuance of this state. The underlying condition is one of chronic inflammation and the surface is an ulcer; hence the habit of the parts is to a continuance of purulent deposits.

In conducting the treatment due regard must be had to the removal of irritation, the establishment of a state of rest, and to such applications as will change the character of the secretions to those of a benign nature or arrest them altogether. The last result is best secured by the application of a mild escharotic, the action of which may be limited to the superficial structures. This is best fulfilled by the use of zinc chloride of the strength of 30 grains to an ounce of water. This, if retained for a few moments, will produce sufficient disorganization of the surface. The pulp should then be well and repeatedly washed with water and kept exposed to the action of the saliva, to dissolve out the excess of the zinc chloride from the eschar produced. The management then becomes the same as for the treatment for the effusion of lymph, and is conducted in substantially the same manner. No attempt toward permanent closure should be made unless a complete subsidence of all the symptoms takes place.

The prognosis of such cases is more unfavorable than of any other class, for the reason that the disturbed state has been of longer continuance and is generally attended by conditions unfavorable to recuperative action.

Traumatic Exposures.—These occur from accidents by fracture of the teeth and by incautious use of dental instruments in the course of ordinary operations. While there is nothing inadmissible in the treatment of pulp-exposures caused by fracture, the results are usually unfortunate, for the reason that the occurrence is usually to front teeth, which are of such small dimensions at the cornua as to render doubtful the success of the mechanical arrangements necessary successfully to cap the pulp in this situation. In the case of accidental or careless uncovering of pulps in the course of excavation of ordinary cavities conservative treatment should in nearly every case be successful.

The treatment indicated is the immediate application of tincture of calendula, which is followed by better results if it is considerably diluted with water. The pulp should then be capped by either a gold or thick platinum cap containing the usual paste of oxide of zinc, carbolic acid, and oil of cloves, when the cavity may be permanently filled. If no displacement of the cap is permitted and no pressure upon the pulp be made, the results are usually favorable.

It is a remarkable fact that when purely accidental exposure of a healthy pulp takes place, if the capping is correctly made and without the least compression, there are no after-symptoms. It is, indeed, a

rare occurrence for the tooth to acquire the peculiar sensibility to cold which characterizes the first stages of pulp-disturbances. Such cases may be filled permanently and at once with gold, if the situation permits it, without any danger of unfavorable results. If untoward symptoms occur, they may be regarded as an evidence of some defect in the manipulation; either the arch of the cap has been forced or it has been displaced in packing the filling. To avoid either result, a large and broad block of gold should be laid flatly over the cap and carefully adjusted about it before the regular filling of the cavity is commenced. By those who have not the skill or the necessary experience the cavity may be filled with a metallic cement.

It should be stated here that all formulas of amalgam to be used as temporary fillings in pulp-cases should be largely composed of tin, like the earlier formula of the Townsend amalgam. This caution is necessary to enable the filling to be easily cut out in case it becomes needful for any reason to remove the filling.

The satisfactory results which follow treatment after accidental exposures raise the question whether Dr. Alport's treatment of the dental pulp, in which a portion of its substance is excised, may not be founded on correct surgical principles. The fact that the pulp does not actually resent operative interference not attended by pressure, that the hyperæmia of the slightly disturbed pulp is confined to the point of exposure, and that protoplasmic elements are probably thrown out in consequence of the excision of the part, would indicate the correctness of this method. While these principles lend support to such a mode of treatment, the sensibility of the organ, the shrinking of the patient, and the difficulty of approach in most instances interpose almost insurmountable difficulties to its successful adoption.

It has also been proposed to remove a portion of the pulp by means of a sharp burr in the dental engine, to which there is the objection of the same difficulties of management, which can rarely be overcome unless the patient be placed under the influence of an anæsthetic.

Prognosis.—The question now arises for consideration, By what means and how soon is recuperative action established in cases of successful treatment? In some instances the pulp will remain without the least disquiet from the moment of covering for a period of from five to ten years, or even longer, and no secondary deposits take place. In these instances it will bleed on being touched, but is not acutely sensitive, and on the covering being re-established the conditions remain as before. It may be stated that in these instances the recuperation is by simple quiescence and equilibrium of the anatomical elements of the organ. In other instances, after so short a period as two years, complete formation of secondary dentine takes place. This may occur when the exposures have been broad.

Consideration of Temperament in Reference to the Prognosis.—The question whether temperament is of any consequence as a factor in the consideration of the probabilities of recuperation in any given case has not received much attention. While the importance of robust health is laid down as a cardinal principle indicative of plastic recuperative effort, and should be regarded as the chief point in this field of observa-

tion, it must be conceded that the various phases of what is called the lymphatic temperament are less favorable to success than any other of the indications of the external aspects of the body. The peculiar manifestations of what is called the lymphatic temperament are indications generally of low vital force, tending to retrograde changes of structure, and for these reasons it should have weight in any consideration of the prognosis. The other so-called temperaments have no unfavorable features and present no difficulties not qualified by other states of health.

Retention of the temporary fillings is required for several years, as the absence of irritation is not an indication that deposits of repair have taken place, since in some instances after many years of entire quiescence no such changes are apparent.

As long as the filling remains protective there can be no excuse for interference, and while the tooth is responsive to a pencil of ice there is no need for solicitude. If the protective filling be of gutta-percha, it should be replaced by one of a harder and more durable character whenever it becomes worn or softened. Generally it is preferable to renew such fillings under these circumstances rather than incur the greater risk of injury from a deficiency of the filling or from an accidental reopening of the case.

Secondary Deposits.—Whenever these occur as the result of treatment, certain peculiar appearances are presented. If the exposure has been of a cornu, there will usually be found a small amount of débris at this point which when cleared away reveals a depression proportioned in size to the degree of the original opening, in some cases there being a decided step down to the secondary bone. When the denudation has been a broad one, the same presence of débris is afforded, which is probably composed of remains of some retained carious dentine and the residuum of the coagulated portion of the pulp. In these cases the secondary bone appears continuous with the floor of the cavity. The demarkation of the new bone is usually distinct, and it is of greater translucence than the normal dentine. Sensibility is usually marked, but is not extreme. It is unfortunate there are no recorded microscopical observations of deposits of secondary dentine of repair formed after capping to throw light upon the mode of its formation.

The advancement in the methods of treating exposed pulps has been so great since intelligent thought has been directed to it that it is among the probabilities of the future that some means of stimulating recuperation of this organ may be devised, instead of the present expectant system of treatment. In this connection hypophosphite of lime and lactophosphite of lime have been employed, but their use has been generally discredited as not grounded in any evidence that the pulp has the capacity to assimilate from substances offered it in this manner the elements for supporting calcifications.

After-disturbances of the Covered Pulp.—For some time after the case has been completed it should be carefully watched and the patient enjoined to apply for treatment on the occurrence of the least indication of uneasiness. As indicated before, the keynote of alarm is hypersensitiveness to cold, and, with this indication in view, it is not difficult to watch the course of any case.

The remedy which possesses the greatest control of the subjective disturbances which may arise is tincture of aconite. The formula should be:

℞. Tinct. aconiti, f℥ij;
Chloroformi, f℥j. M.

The indication for this application is an increase of any of the symptoms.

The mode of application to prevent an excess being used and to avoid any portion escaping into the mouth, from whence it might reach the throat and otherwise produce unnecessary annoyance and danger, is partially to saturate a pledget of cotton the size of the ball of the finger, to squeeze out the excess between the folds of a napkin, and then to lay the pellet upon the gum at its juncture with the cheek, where it is permitted to remain for a couple of minutes. Previous to the application being made the surface of the gum should be cleansed of the coat of mucus by a napkin or fold of soft paper. Relief, although not immediate, is pronounced in remediable cases within a few hours, one application in many instances being sufficient. Discouragement should not be felt if recurrence of pain should occur, as recovery has taken place in the writer's experience when repeated applications were required. In one case in particular, where a covering had existed for thirteen years, on the partial loss of the filling evidences of irritation of the pulp occurred, which was attributed to another tooth, treatment being, therefore, delayed. On the final discovery and recapping the disturbance continued for a month with many exacerbations, which finally yielded to the frequent applications of aconite in the manner described.

Should there have been continued subjective disturbance to any notable degree before the treatment of any given case, as has been stated, an application of the above remedy should be made to the gum at the close of the operation.

This formula relieves by the counter-irritation resulting from the slightly vesicant action of the chloroform, as well as by the sedative control which it enforces upon the local nerves. Another use of the chloroform is to facilitate the absorption of aconite. Should the symptoms become pronounced, it is advantageous very superficially to scarify the surface of the gum with a sharp lancet in several closely contiguous lines; this increases the counter-irritation. It has been claimed that aconite locally applied has some power to reduce the calibre of the capillaries, but this does not appear to have been verified by physiological experimentation. When objective indications are presented it becomes important to add tincture of iodine to the above formula, thus:

℞. Tr. aconiti, f℥j;
Tr. iodi, f℥ij;
Chloroformi, f℥j. M.

This is in agreement with clinical experience, and appears to exert considerable influence over the early stages of inflammation of the peridental membrane.

The after-treatment of capped pulps is of very considerable import-

ance, as will appear from the consideration that the purpose of it is to reduce the nervous irritation in order to prevent the occurrence of undue vascular excitement. When there has been no history of disturbance, it is always well to make at least one application of the preparation of aconite. When there have been indications of nervous excitement of the pulp, in nearly all instances there will be a continuance of the disturbance for several days, which, if neglected, might run so high as to cause determination of blood. It is therefore always necessary in such cases to make one application at the time of the operation, and to repeat it in a couple of days. The patient should be admonished to apply at any time after the treatment should there be an increase of sensibility to cold or a recurrence of any of the previous symptoms.

In the class of cases where the degree of disturbance has become notable all chances of success depend upon maintaining close relations with each one until the objective symptoms have passed away and the subjective ones have commenced to decline.

A final summary of the results of conservative treatment of the pulp may be formulated as follows:

1. When accidental exposures have taken place, recuperation may be regarded as entirely probable.
2. Where exposures have existed without any excitement of the nervous elements of the pulp, the results of treatment carefully conducted are usually successful.
3. When, after continuance of the changed relations, the pulp has become irritated by chemical influences and some subjective indications of disturbance have arisen, the tendency is to recovery when the conditions are attended by states of bodily vigor.
4. When the exposures have been of long continuance and from any cause objective symptoms have ensued, the probable results of treatment become more uncertain; nevertheless, in healthy subjects recuperation may take place.
5. When, after complete, or nearly complete, uncovering of the pulp to atmospheric influences has occurred, the results of treatment become doubtful and speculative. If the state of health be vigorous, recuperation in some cases takes place. With those of low bodily tone failure is the probable result.
6. Where chronic conditions have become established, the results are increasingly speculative, and no relief can be reached without destruction of the pulp.

Report of Cases of Treatment.

The subjoined cases are from the writer's note-book, which contains the records of over four hundred cases of conservatively-treated pulps made since 1869. During the first half of the period, while there were notable successes, many of the cases were failures from the occurrence of congestive conditions of the pulp. In the latter half of the period the results have been more satisfactory, in consequence of the care and discrimination enforced by greater experience. In such a field of treatment, however, the procedures are necessarily often of a tentative nature, and

failures are to be expected from the existence of unfavorable conditions, and also from such situations of pulp exposures as preclude complete control of the capping. Among the great number recorded, a multitude are in a state of quiescence, no attempt having been made to determine their condition beyond the tests for vitality; of these, a great many selected cases belonging to divisions 1 and 2 of the summary are filled with metal, including gold, tin, and amalgam. Of recoveries by deposits of secondary dentine, there have been twenty-three among those which have been opened for the purpose of repair or inspection.

Recovery by Development of Secondary Dentine.

Accidental Exposures.

Case 1. *Lingual Surface Left Upper Central.*—Presented May, 1869. The cavity in this case appeared of small calibre, but in excavating the pulp was suddenly and without warning accidentally touched, when it bled. Proper applications were made and the cavity was closed with gutta-percha. There was a little uneasiness for a few days, but from that time to this there has not been the least pain, and at repeated examinations since the treatment the appearance of the tooth has indicated the possession of full life. The case was re-examined April 2, 1872, with every evidence of a vital pulp. The cavity was subsequently filled with gold, and the tooth remains vital at the present time.

Case 2. *Mesial Surface Right Lower First Molar.*—Presented February 5, 1875. Slight accidental exposure. Applied calendula and covered with oxide of zinc and carbolic acid protected with gutta-percha. Restoration by deposition of secondary dentine observed April 14, 1882.

Case 3. *Mesial Surface Right Lower First Molar.*—Pulp accidentally exposed in 1872 or 1873. Filled as usual in these cases. Re-examined February 13, 1884. Cavity opened and carefully uncovered. The part of previous exposure was found filled with secondary bone. Stopped with gold, using a trace of varnish on the new dentine.

Case 4. *Mesial Surface Left Lower First Molar.*—Presented October 23, 1883. Pulp accidentally exposed. Capped with gold plate. Treated as usual, and filled with gold. Afterward became decayed at margin; point of exposure apparently healed over. Dentine still sensitive. Filled with gold October 27, 1885.

Ordinary Exposures.

Case 5. *Mesial Surface Left Lower Second Molar.*—Presented January 20, 1873. Inner cornu fully exposed. Bled. Had pain both locally and by neuralgic reflection. Treated as usual, applying calendula. Opened and presented May 4, 1878. Found pulp alive and dentine extremely sensitive at the margins. Pulp on being uncovered bled a little. Covered again, using dilute calendula. There had been no pain in the period of five years. Reopened December, 1885. Found the tooth sensitive at the margin. Old point of exposure completely obliterated by secondary deposit. Some detritus found over the place of exposure. Filled with amalgam, using a thin layer of gutta-percha as a non-conductor.

Case 6. *Mesial Surface Right Upper Second Molar.*—Presented October 1, 1877. Some previous pain, attended by neuralgic symptoms. Aconite, 50 per cent. sol. carbolic acid, and glycerin mixed with oxide of zinc, covered with oxychloride of zinc. Opened March 1, 1886. A case of recu-

perated pulp. Tooth sensitive at all points of the outer margin. On laying bare the bottom of the cavity a little débris was found at outer cornu, surrounded by an area of slightly darkened dentine. There was a light spot slightly depressed, which is evidently the site of a deposit of secondary dentine. The tooth during the whole period had never been the subject of any sensation. Filled with amalgam.

Case 7. *Mesial Surface Left Lower Second Molar.*—Pulp found exposed early in 1871 at both cornua. January 12, 1872, it was opened, when no apparent change in the appearance was observable. Aconite was applied, also carbolic acid and glycerin, and carefully covered, but there was some sensation when the gutta-percha was introduced—probably occasioned by pressure. January 20 the patient returned, having had some pain for three days, which appeared to be increasing in intensity. The appliances were removed. The pulp bled. Aconite was applied, and in a few minutes afterward pure carbolic acid. The pain was entirely removed. Sent note to patient January 29, and received reply: "It has given no further trouble since I last saw you." September 12, 1876, opened and examined in the presence of Dr. Essig, when the cornua were found entirely solidified. The case was then permanently filled. Reopened April 23, 1885. Found healthy and all parts of the tooth sensitive.

Case 8. *Left Lower Wisdom.*—Very large cavity. This pulp had been exposed by some previous operator, treated in a manner not explained, and filled with amalgam. Patient suffered pain and had the filling removed and replaced very soon afterward. After four years, on opening it, found a deposit of secondary bone covering the whole extent of pulp-chamber. The probabilities are that the pulp was exposed at a small point, and that subsequent decay had destroyed the ordinary dentine, the secondary deposit resisting further decay. The dimensions of the surface of deposit were three lines by one and a half lines. After removing the decay from all parts of the cavity it was dressed with carbolic acid and filled with gutta-percha on April 21, 1879.

Case 9. *Mesial Surface Right Upper First Molar.*—Presented September 22, 1876. Full exposure. No previous pain. Oxide of zinc, carbolic acid, amalgam. Reopened June 30, 1881. Within the point of exposure, at a distance of a half line, there was found a deposit of secondary dentine; complete sensibility at all points.

Case 10. *Mesial Surface Left Upper Second Molar.*—Presented April 19, 1878. Pulp found very slightly exposed at middle portion. No previous pain. Applied aconite and carbolic acid, 50 per cent. solution. Point of exposure carefully covered with pellicle of gutta-percha. Cavity immediately filled with gold. Secondary dentine at point of exposure found at refilling on December 9, 1884. Refilled with gold.

Case 11. *Mesial Surface Left Upper First Molar.*—Presented January 27, 1882. Pulp exposed. Treated as usual. Filled with gutta-percha October 30, 1885. Temporary filling lost in previous July. On opening case some caries was found; on removal of this there was revealed a deposit of secondary dentine, including the inner cornu and extending nearly to the outer one. The pulp was nearly exposed at the latter point, apparently by the renewal of the decay. Covered pulp with cap and filled the cavity with amalgam.

Case 12. *Distal Surface Left Lower First Molar, Buccal Cornu.*—Presented February 5, 1873. Application of patient preceded by slight neuralgic symptoms. Treated as usual. Temperament bilio-lymphatic. November 25, 1885, recovered by deposit of secondary bone.

Case 13. *Mesial Surface Left Upper First Bicuspid.*—Presented September 6, 1883. Previous slight neuralgic pain in the front teeth, particularly in the lateral incisor. The cavity was deep enough at one point to expose the pulp, but it could not be seen. There was a moment's pain on covering with the cap. Deposit of secondary bone. March 10, 1886, refilled.

Case 14. *Mesial Surface Right Lower Second Molar.*—Pulp exposed. Treated as usual. Filled with gutta-percha probably about the year 1879. Re-examined March 12, 1886. Tooth has not been opened meanwhile. The pulp had evidently been exposed at outer cornu, where the cap was found. After removing a little débris the point of exposure was found to be obliterated. The usual incomplete ring of discolored bone was found, in the centre of which was a clear yellow spot. The tooth was fractured at coronal margin, and some decay occurred along the inner border, which exposed the pulp at inner cornu. Treated again as usual.

Case 15. *Distal Surface Right Upper First Bicuspid.*—Presented July 21, 1866. Pulp exposed. Portion of caries was permitted to remain, which was saturated with solution of hy. phos. cal. in glyc. and water. The tooth remained unopened, except an occasional renewal of the exposed portion of the gutta-percha, until September, 1872, when the cavity was perfectly cleansed. At the points of original exposure an undoubted deposit of secondary dentine was discovered. The cavity was then permanently filled. During the long continuance of the temporary filling no pain had occurred after the first few months.

Case 16. *Distal Surface Right Lower First Molar.*—Pulp exposed. Treated as usual in April, 1878. Recovery by secondary bone, May 3, 1886.

Case 17. *Distal Surface Left Upper Central.*—Pulp exposed. Filled with gutta-percha October 10, 1882. Re-examined April 1, 1886. The point of exposure protected by secondary bone. The tooth sensitive at all points.

Cases Illustrating Great Recuperative Power.

Case 18. *Distal Surface Right Lower First Molar.*—Presented autumn, 1870. Exposure undoubted: seen and touched. Filled temporarily, as usual. Re-examined November 8, 1872. This case has given no pain in the interim. Opened, and found pulp alive, and, unfortunately, wounded it. Applied calendula and carbolic acid, and covered as usual. Patient removed to Europe, when the cavity was filled with gold, which was tolerated for a day only. March 6, 1885, fully responsive to cold. April 27, 1886, still alive.

Case 19. *Outer Surface Left Lower Wisdom.*—Some previous slight disturbance. Applied aconite and carbolic acid. Covered with gutta-percha April 13, 1879.—*Same tooth* in lingual surface, pulp fully exposed, December 10, 1882. This case is remarkable as being exposed and treated in two places without the occurrence of any after-pain.

Case 20. *Distal Surface Left Lower First Molar.*—Treated 1872. Exposure at a cornu; 1874, some sensibility to heat; April 11, 1878, responsive to cold. Subject of previous exposure of the pulp at cornu, as heretofore reported. Cavity had been filled with amalgam after it was considered safe so to do. Subsequently decay occurred along the cervix, exposing the pulp at another place. Previous pain at night, also some neuralgic pain on that side of face. Bone was highly sensitive. Treatment with

aconite, carbolic acid, and oxide of zinc, covered with gutta-percha, April 9, 1879. Immediately after the filling of cavity there was so much disturbance of the pulp that the patient applied for relief, which was furnished by tinct. aconite. In the interim there has been occasional sensitiveness to cold and to the pressure of hard food. To-day (February 12, 1880) tooth isolated and found sensitive to ordinary cold water.

CASE 21. *Mesial Surface Left Upper Second Bicuspid.*—This case was attended by several peculiarities. The patient complained for a year of pain, which was referred to the adjoining capped pulp, but which never yielded to the proper applications. The pain was intermittent. Affected by cold, and occasionally by soft bread. Opened an adjoining pulp-case and found it healed by a secondary deposit. Diagnosed another exposure, but the tests did not reveal it. Examined later, when the tooth responded to cold. On opening by removing a gold filling, found a minute aperture exposing the pulp. Treated as usual, applying calendula and aconite, which was followed by quick relief, May 13, 1886.

CASE 22. *Mesial Surface Left Upper Wisdom.*—Apparently an old exposure, and had been exposed to the air for several weeks. Some superficial devitalization at one side of a long but narrow exposure. Applied carbolic acid, zinc chloride, 20 grains to ounce; capped as usual and filled with amalgam, June 21, 1884. June 2, 1886, examined, and found responsive to cold.

DEVITALIZATION OF THE PULP.

When, for any reason, it becomes necessary to deprive a tooth of its living pulp, there are presented four problems:

1st. To accomplish this object with but little pain;

2d. With quickness;

3d. To prevent discoloration of the dentine;

4th. To lessen the probabilities of future disordered conditions of the surrounding structures.

These qualifications are related in a regular sequence. Thus, if the pulp is destroyed without pain, the action is prompt and the occurrence of injurious consequences is much less probable. Hence the salient elements of the treatment is found in the first statement.

There exists some diversity of opinion in reference to the best means to accomplish these results. There are but two general processes—by the chemical action of some escharotic or by extirpation with suitable instruments, each of which methods has its disadvantages and peculiar difficulties. The former method is the one which has been in most general use. It may be effected by the employment of—1, zinc chloride; 2, caustic potash; 3, chromic acid; 4, carbolic acid; 5, arsenious acid; 6, arsenical oxide of cobalt. The agents Nos. 1, 2, 3, and 4 are usually either slow, painful, or uncertain. The chemical most relied upon is arsenious acid, which has been in general use for a long time, and which, notwithstanding certain objections to be hereafter stated, is the most convenient and reliable of any of the chemicals mentioned. It is usually employed in conjunction with morphia sulphas or morphia acetatis and carbolic acid. The morphia is combined with the arsenic as a sedative to lessen the severe pain sometimes occasioned by the arsenic, and the carbolic acid is used as a convenient men-

struum, it also having the power to immediately combine with the elements of the surface of the pulp, and thus prepare the tissue to absorb a portion of the devitalizing agent. The formula may be considerably varied without materially altering the result, but it is generally thought best to have the morphia in the proportion of two to one of arsenious acid. The consistency of the paste should be thick enough to prevent the subsidence of the arsenious acid, which, on account of its greater gravity, tends to descend. Some claim that pure powdered arsenious acid following an application of carbolic acid is more satisfactory than when combined in the form of a paste. This view, however, has not a wide acceptance. It is an important qualification that the trituration of the ingredients be long continued, first in the dry state, and afterward when the carbolic acid is added. At the moment of use a portion of this paste should be thinned to a convenient consistency with carbolic acid and oil of cloves, to which a little glycerin may be added.

How to Apply the Paste.—The pulp should be uncovered by removal of the carious matters and be dried. This latter is a feature of considerable importance, since if the surface of the pulp be wet there is not proper action of the carbolic acid, as it has a weak affinity for water; hence the effect of the paste is delayed. The point of exposure should be touched by a small quantity of the paste, either by means of an instrument conveying it by a minute piece of cotton saturated with it, or by a sharp broach, the point of which, having been charged with a portion, is pricked into the tissue. In this connection it should be noted that it is of great importance to avoid the excessive use of the paste, and to confine it to the pulp, as very considerable injury may be done to the surrounding structures of the tooth by injudiciously using either an undue quantity of it or by forcing a portion of it against the gum.

When the application is made, the preparation should be covered by a cap of sheet tin, as described in the previous section in connection with the subject of pulp-capping. The purpose of this is to protect the pulp from the pressure of the temporary outside stopping. In very many instances of attempted devitalization of the pulp the pain occurring has been produced by the pressure of the dressing, and not, as has sometimes been supposed, by the irritative action of the chemical agent.

The Temporary Closure.—The important qualification of this dressing is that it shall exclude outside moisture, and that it shall be easily removable at the proper times during the course of the treatment. Cotton with which wax has been combined, as recommended by Dr. Maynard, cotton partially saturated with sandarac varnish, and gutta-percha, are each admirable when the circumstances permit. Should there be danger of bleeding of the pulp or should the pulp be congested, the second substance is preferable, for the reason that it is capable of taking up a portion of the blood and thus lessening the danger of an extravasation of blood, which is liable to result in discoloration of the tooth. The discoloration of the teeth when they have been devitalized is to be attributed to disorganization of the blood-corpuscles and the infiltration of the dentine to a greater or less degree by the coloring matter of the blood, and not to the mere exposure of the dentine to the presence of a hemorrhagic coagulum. It has been pre-

viously shown that the pulp in states of congestion is peculiarly prone to disorganization of the blood-corpuscles, which occasions the dark patches not unfrequently observed in its structure after this condition has existed. One of the marked tendencies of the action of arsenious acid is to bring about this result; and this is more likely to ensue if no outlet is furnished for the escape of effusions if congestion occurs in consequence of the action of the poison. In the older treatment of the pulp, when fewer precautions were taken than in recent times, and when arsenious acid was used without first properly exposing the pulp, the most serious discoloration of the teeth was common. Another means by which this danger may be obviated is, when the nature and situation of the case may permit, to make the cap large enough and sufficiently convex to contain any probable amount of escaping fluid, at the same time permitting capillary communication by a small outlet at one side of the cap. When there is no danger of congestion the covering may be made of either waxed cotton or gutta-percha.

The time of retention of the applied poison has no determined limits. In some instances after about a day's interval the pulp of the single-rooted teeth will be found insensitive, and may be removed; in other instances the extent of the action is simply superficial, and it has to be repeated. When the pulp is quickly impressed by the poison, it has been claimed that it has not extended throughout the tissue, but that it has destroyed the sentiency of the organ by paralyzing the nerves in a manner which at present is not capable of satisfactory explanation. It is better, therefore, to examine the pulp under this process at the end of twenty-four hours, and to make the attempt to pass the broach to the end of the fang. If this proves to be inadmissible, the best recourse then is to repeat the application of the poison to the devitalized portion without making an attempt to remove this part. The practice of many has been at this stage to tear away the devitalized portion. Besides inducing annoying hemorrhage, this method jeopardizes the successful application of the arsenical paste—first, by the bleeding preventing the arsenic from being placed in exact contact; and second, when the action has extended into the roots some distance there is danger of the poison being rubbed off upon the walls of the canal. But when it is found that the devitalization has extended to near the apex of any one of the fangs, the filament may be removed from this fang or it may be cut away from the body of the pulp, and the action continued until the pulp in the other roots is dead.

The second application should be very minute in quantity and be allowed to remain for several days.

It does not always happen that when the pulp must be destroyed by the direct combination of the arsenious acid with the tissue that this will be effected by even a second application. To determine how far the poison has extended downward, a fine watchmaker's broach, from which the temper has been reduced to a little softer quality than is usually indicated by blueness of the surface, or a steel nerve-bristle, is carefully pushed upward beside the pulp. In this way the exact point to which the poison has gone may be measured.

The directions here given are for application to ordinary exposures

which present no difficulties. There frequently arise complications which require considerable modification of these simple means.

Since the method of conservative treatment of the pulp has become established on a better basis the dental pulps which are relegated to destruction are frequently not in a favorable condition for immediate devitalization. They are in such a state of nervous and vascular excitement that the application of arsenious acid will not be attended by favorable results. Similar conditions of the pulp occur when no attempts of this nature have been made, but when the indications determine that the pulp is in a state of congestion or of approaching congestion. It has become an established fact that when arsenic is applied to a pulp in this condition it frequently increases the excitement without producing the least destructive action upon the tissue to which it is applied. This is in agreement with well-known facts in relation to the effect of arsenic on the stomach, where, if given in great excess, the danger from its use is less than when a smaller quantity may have been administered. The indications are that before this poison can enter into combination with the tissues the nervous force of the tissue must be paralyzed. Hence in states of inflammation and congestion, when the nervous sensibilities of a part are exalted, the absorption or combination of the poison with the tissue is neutralized.

These considerations, and the facts in support of their force, lend strength to the opinion that it is inadmissible to apply the arsenious paste to pulps which are presented in the above condition. What, then, shall be done? The indications are that the excitation of the organ should be diminished, and when this is brought about the administration of the paste should be made in such great dilution and in such combinations as may not produce excitement.

The means to accomplish the quiescence of a disturbed pulp have been detailed in the preceding section "On the Treatment of Congested Pulps." Suffice it here to say that lessening of pain and economy of time are gained by delaying the process of devitalization until the period of exalted sensibility has subsided.

An excellent dressing to secure the tranquillity of a congested pulp is to apply the appropriate remedy to the pulp, covering it with a well-arched cap of tin, under the edge of which is placed a large-sized broach. Over the whole a gutta-percha stopping may be placed, and when this is cool the broach is withdrawn. This leaves a small channel through which gases and the exudations of the pulp may escape. It is obvious that to prevent the food from being forced into this aperture the course of it should be in a lateral direction.

Bleeding pulps require to be somewhat similarly treated to permit the free escape of the blood, for if this be dammed in the cavity by the dressing, discoloration of the teeth is an almost certain consequence. As stated before, the bleeding renders futile an attempt to make the application of the paste. It is necessary to check it by a styptic, tannic acid being probably the best, or to delay the commencement of the treatment until another day; which, on the whole, is the better course to pursue.

When the pulp is found partially devitalized there is no reason why

an immediate application of the poison should not be made; but as such cases are usually attended by exudation either of lymph or of pus, the preferable course is to prick the arsenic into the tissue with a broach, since the exudate from the surface is liable to prevent contact of the preparation.

When to Attempt the Removal of the Pulp.—The degree to which the poison may be permitted to extend downward into the pulp has been the subject of much discussion. The general opinion of careful operators supports the wisdom of removing this tissue before the effect of the arsenical action has reached the end of the fang. The best results appear to favor the removal of the pulp when the point of sensation is found a full line from the end of the canal. At this stage of the devitalizing process there is usually so little pain in the removal that it is no impediment to the operation. When the demarkation is determined to be sufficiently deep, the removal of the pulp should be effected by the rotation of the five-sided broach. It is generally easy at this stage to carry the broach downward to the apex, where the fine end of the pulp may be wrapped upon it if rotation is made of the instrument. In some instances, however, the pulp appears to be devoid of sufficient consistency for this, when it must be taken away piecemeal by barbed broaches.

Fig. 117.

Donaldson's Nerve-bristles (*Cosmos*).

If the pulp be quickly devitalized its consistence is such that it is readily caught upon the broaches and easily withdrawn; but if several days elapse it loses its toughness and breaks into fragments. In the latter case a sense of uncertainty may exist as to the removal of all portions of the dead matter.

The hooked broaches commonly in use for this purpose are of little avail, since, except for the removal of the bulbous portion of the pulp, they tend to push up the contents of the fang and compress the dead portion against the small remaining portion of the still living tissue at the apex. This may create the impression that the destructive action has not extended nearly so far as it may have done. For the removal of this apical portion of the pulp the broach should be sharp at the point, and yet not so acute as to pass through the foramen. It should be barbed slightly on one side, to facilitate the clinging of the shreds of tissue. The nerve-bristles of Dr. Donaldson, herewith figured, are very useful. The Swiss watchmaker's broach is also admirably adapted. This implement has various uses as an adjunct, and when not too much softened it is the least liable to be broken of any similar form of nerve-broach. An expert person will draw the temper over a lamp-flame and scarcely ever fail of correct tempering. The proper softness can be given to the Swiss broach by holding it sufficiently far above a small alcohol-flame to prevent too much heating. By commencing at the heel, the change of color may be obtained and the passage over the flame regu-

lated. The correct color is the grayish tint which follows the blue shade. The barbing may then be made on one of the corners with an enamel chisel. These delicate instruments may be carried in the Butler broach-holder or any suitable handle which will grasp them. The treatment of the pulp can hardly be carried on without a great variety of sizes of this implement.

Disturbances following the Removal of the Pulp.—Sometimes there immediately occurs after the removal of the pulp a more or less disturbed state of the peridental membrane. This has been attributed to two different causes: to the influence of the arsenic, and to the fact that the blood which supplied the pulp has been, by the destruction of this tissue, distributed upon the membrane at the apex of the root. Here it is pertinent to enter into the inquiry whether arsenious acid may be a primary cause of this condition, or whether it may not be due principally to the secondary influences of this agent.

From the early period of the use of arsenious acid as a devitalizing agent of the dental pulp there have been objections made to its employment based on the allegation that a portion of the poison may attack the peridental membrane. All the train of consequences which sometimes follow the death of the pulp in the manner described have been attributed to the effect of arsenic. There does not appear to be any warrant for such a supposition when the action of the paste has been limited to the pulp itself by close observation of its progress, and the removal of the pulp before the poison has had an opportunity to get beyond the confines of the pulp-canal. Neither does the progress of arsenic in the generality of cases take place with such rapidity, when it is administered in the small quantities required, as to cause any serious concern that it may quickly pass to the end of the root. Instances have been recorded where it has been applied to the pulp and allowed to remain for many weeks without depriving more than a portion of the pulp of life. The writer in one instance in the early period of his experience, when it was considered dangerous to have the paste remain longer than twenty-four hours, had a patient disregard his engagement and remain away for three months, when the action had not reached to the end of the canal. The cause of dangerous effects, when they occur, must be attributed to the employment of an unnecessarily large quantity, which finds its way to the exterior tissues by capillary action after it has effected complete devitalization of the pulp.

There is, however, one way in which this agent may produce lesions of the peridental membrane. It has been shown in the section on the "Conservative Treatment of the Pulp" that in its congested state the capillaries of the pericementum become affected, and that this condition may extend to a considerable portion of the membrane.

If during the attack of odontalgia the death of the pulp is determined upon, and this condition of the membrane has supervened, it is not difficult to accuse the remedy of producing an effect which is already in existence, and which may have been overlooked when masked by other disturbances. Under these circumstances the action of arsenic increases the determination of blood to the peridental membrane by adding to the already existing irritation.

It has been laid down at the commencement of this section that two of the most important and salient considerations in destroying the pulp are to do it promptly and with little pain. When the conditions do not render these results easily attainable by any chemical agent, there remains the immediate extirpation of this organ as a solution of these requirements. This method offers the quickest method of accomplishing the removal of the pulp, but the instances are rare when it can be painlessly done.

Extirpation of the Pulp.—There are certain advantages secured by the immediate removal of the pulp which are obvious in view of the risks of disturbance which arise as attendant consequences of its devitalization by chemical agents. There are also circumstances, such as extreme limitation of time, which require an immediate extirpation to avoid the unavoidable delays of the described method. The extirpation may occasionally be done under the unusual conditions of entire absence of sensibility of the organ. Although an exposed pulp may be touched without pain, it is not once in a thousand times a patient will permit the severe handling involved in thrusting an instrument through or beside the pulp to the apex of the fang, and then by rotation of the instrument dislocating it and effecting its removal. Frequently as this operation is described in textbooks, its practical execution must be considered one of great rarity. There are, however, instances when the pulp may be extirpated without more than a slight degree of sensibility.

It has been pointed out how impatient the dental pulp is of the least compression; and it is for this reason that few patients can be induced to have the attempt at extirpation made. In case this operation be decided on, a fine smooth broach with a few barbs at its point should be inserted beside the pulp at its coronal portion, and be quickly carried to the end of the fang, where it is rotated to cut off the filament. Another means has of late been proposed and practised—of sharply driving a slender splint of hickory wood by a single blow of the mallet entirely to the end of the fang—a movement which is said to be so suddenly accomplished that it immediately paralyzes all sensation. But it must be said that at this time this means has not gained much advocacy.

It is obvious that the attempt to remove the pulp by immediate action must be preceded by a careful enlargement of the orifice of exposure to such a degree as to give full and free access to the opening of the root or roots. This is in most instances quite a formidable and painful process, and tends to lessen the opportunities for its performance. The pulp while this preparation is taking place should be obtunded by repeated applications of chloroform or of veratrum, as recommended for the treatment of extreme sensibility of dentine.

Use of Anæsthetics.—When extirpation cannot be performed, and, because of the danger of pain attending the use of arsenic, it is desirable promptly to remove the pulp, the use of an anæsethetic is justifiable. Under the influence of ether the operation is usually easily done. It is necessary, however, to carry the administration of the anæsthetic so far as to produce complete unconsciousness, else the movements of the patient in any position but those of the easiest access will thwart

the object in view. While extraction of the teeth, the opening of abscesses, and cutting of sensitive dentine may be performed in the first stage of anæsthesia, during which the patient may be intelligently conscious, the removal of the pulp in the same state would not be tolerated. Even in an anæsthetic condition approaching stertor the automatic movements are frequently considerable.

The advantage, however, of removal of the pulp in this manner warrants the trouble when an anæsthetic is admissible. The only substance suitable and safe to be used for this purpose is the purest sulphuric ether. Dr. Squibbs's, on account of the extreme care with which it is prepared, is preferable to any other. There is considerable advantage attending the removal of the pulp under the influence of ether which is worthy of extended notice. The preliminary preparation of the orifice of exposure is entirely avoided. This may be delayed until the patient is insensible, when all the steps connected with the operation may be carried out. The general form of the outer cavity, however, must have been previously so shaped as to give easy access to the point of exposure.

The use of cocaine in various forms has been lauded by several practitioners as offering an efficient local anæsthetic which makes possible, it is alleged, the painless extirpation of the pulp. This is entitled to extended trial, as none other known local obtundent has afforded any anæsthetic action beyond permitting the removal of the mere surface of this organ.

After the devitalization of the pulp has been effected it becomes necessary to prepare the pulp-chambers and canals in such a manner as may facilitate imperviously filling them. In nearly all cases before the pulp is completely destroyed it is required to alter the form of the carious cavity and the opening to the pulp-cavity to enable the fangs to be entered by the instruments. In some instances new openings have to be made in the tooth in such a position and by such a direction as will permit the canals to be easily explored.

After the pulp is destroyed there are two essential elements of the treatment to be fulfilled: the removal of all the dead tissue, and the complete filling to the apex of the pulp-canals with some substance which is of an indestructible character and incapable of absorbing any organic matter. On these cardinals rests the procurement of conditions which furnish the only assurance of safety from future diseased states of the peridental membrane. Unless all of the dead pulp is taken away the portion remaining is likely to become putrescent and exert septic action. If the fangs are not occluded throughout or are loosely filled or filled with some substance capable of saturation, the result at length will be the same: the organic matter, entering the canal by capillary action or becoming absorbed by the filling material, at length almost invariably excites septic disturbances. The practice has been sometimes advocated of filling the canals in such a manner that when disturbance at the apex occurs the trouble may be reached by removing the filling and giving outlet to the septic matter and to any other secretions which may have been produced in consequence of its presence. This, on examination, does not appear to be founded on rational grounds, since it is well estab-

lished that the organic matter which must accumulate in the apex or imperfectly-filled canals sooner or later exercises an exceedingly poisonous influence upon the tissues at the apex. From this consideration it would appear a reasonable conclusion that the only correct course is to preclude the opportunity for the entrance of organic fluids. Neither is this so-called prudent plan founded on experience, since observation has shown that such teeth at length become the seat of alveolar disturbances and the establishment of fistulas of an intractable nature. Careful management, combined with complete closures, is rarely followed by any after-inflammation of the root-membranes, and when it occurs it is amenable to externally applied antiphlogistic and sedative treatment.

The methods by which the canals of each class of cases may be reached for treatment will now be detailed.

The Central Incisors.—When the cavity of the proximate surface is of considerable size, such as represented by Fig. 118, a channel having the form shown by the shaded portion is made from the cavity of decay to establish free communication with the root-canal. The position of this channel is somewhat toward the tuberosity of the lingual surface. The cutting to produce this may be made by small gouge-cutters or by the withdrawing cut of a rose-drill in the engine. If by the latter means, a small drill is entered into the pulp-chamber at this point, when it is withdrawn and made to cut during this movement. By several such movements the correct form is produced. Done in this manner, the marring of the opposite side of the chamber is avoided, which, if it occurs, may prevent the ease of the subsequent filling process.

Fig. 118.

When the proximate cavity is small, it weakens the tooth less to cut in from the lingual aspect of the tooth. The opening should be made at the commencement of the basilar ridge, and the direction of the drilled channel obliquely downward and outward. This is shown at Fig. 119.

This opening should be commenced with a small drill, care being exercised that it be not permitted to pass beyond the lingual wall of the pulp-chamber. It may next be increased sufficiently to permit the use of the cleansing and filling instruments. Before these can be employed it is necessary to remove the intervening angle between the canal and the artificial opening.

Fig. 119.

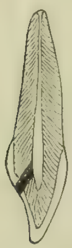
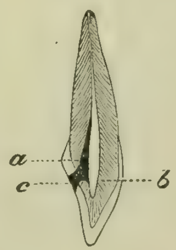


Fig. 120.



In Fig. 120 is shown the change of form which permits the passage of the delicate instruments required in the next steps. The form at *a* permits the instruments to be inserted in the vertical direction. Cutting should also be made at the acute angle formed at *b*, to permit removal of the débris from this portion of the pulp-chamber, and to allow the dependent part of the chamber to be filled.

This situation for, and mode of, opening into the pulp-chamber of

front teeth should always be selected when spontaneous or accidental death of the pulp takes place.

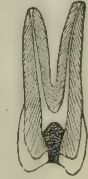
The Lateral Incisor.—On account of the smallness of this tooth the opening into the pulp-chamber should, whenever admissible, be made from the proximate cavity, in the same manner as described for the central incisor.

The Upper Cuspid.—The opening into the pulp-chamber of the cuspid should always be made from the proximate cavity, for the reason that a drilled opening on the inside, in addition to the carious cavity, too much weakens this tooth. The form of this tooth usually favors opening the pulp-chamber from the proximate aspect.

The Upper Bicuspids.—The direction of approach should always be from the cavity if one exists. This is best done from an anterior cavity, and should be conducted by making two openings opposite each root, cutting them by a withdrawing movement of a small rose-drill or by a hooked bone-cutter. The partition between these openings is next cut away in any suitable manner, the result giving the same accessibility as described for the front teeth.

On account of the small size and frequent union of the roots of the bicuspids the preparation of the channel of approach to the canals requires more care than those of any other of the teeth. At the same time, caution must be exercised to avoid weakening these frail teeth by extensive cutting to secure free access.

Fig. 121.



It should be here noted that because of the fossa between the cusps of these teeth they are extremely liable to fracture, this danger being increased by the loss of vitality. Whenever it is required, a portion of the inner cusp should be ground away. Whenever the pulp has become devitalized in a sound tooth, the opening should be made by a round passage from the coronal surface, the inner direction of the opening conforming to the dimensions of the pulp-chamber, as shown in Fig. 121.

The Upper Molars.—The upper molars usually have their roots well defined. The canal of the inner one, being of considerable size, is easily entered to permit the removal of the dead tissue and to effect the filling of the canal. The buccal roots nearly always are small, which renders the removal of the pulp and the filling of the space exceedingly difficult, and in many instances it is made impossible by their minuteness. When this is the case, the endeavor to extend the action of the arsenious acid to the end of these canals may be omitted. An approximation of their size may be made by an examination of the forms of the teeth; thus, when the teeth are narrow at the necks the evidence is complete that the canals will be correspondingly diminished in diameter. In such cases, and sometimes in the narrow canals of the lower molars when the pulp-filaments can only be removed for a short distance, the end of the remaining portion should be acted upon by a drop of deliquesced chloride of zinc, after drying out as well as possible the infundibular portion of the canal.

Fig. 122 shows the anatomical relation of the pulp-canals of these teeth: *a*, the form of the pulp-chamber at its base, and *b*, at the opening of the roots.

When the carious cavity is upon the coronal surface, the bottom of the cavity should be cut away to the outline of the chamber. This permits the fullest access to the fangs, and is shown at Fig. 123.

When the cavity is upon the mesial aspect, the cutting is in accordance with the plans already laid down. It should be extended across

FIG. 122.

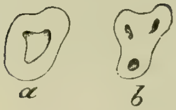


FIG. 123.

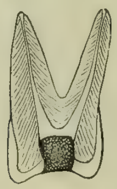
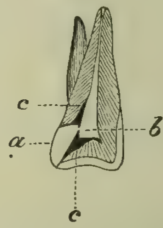


FIG. 124.



a, represents the carious cavity; *b*, the pulp-chamber; *c*, the cutting to give access.

the lateral dimension of the pulp-chamber. It is also necessary to deepen the channel of approach of the outer cavity. (See Fig. 124, mesial.)

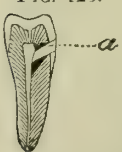
Where the carious cavity is upon the distal proximate surface, an additional opening is frequently required through the crown of the tooth from the coronal surface, as shown at Fig. 123. When the cavity is large and the buccal root-canals so extremely minute as not to require filling, their orifices may be made accessible from the carious cavity; but when these roots are large, there appears no escape from making this additional opening through the crown. When the canals of the buccal fangs will admit a broach of the size of No. 27 (wire-guage), they may be filled with either gold or fluid gutta-percha.

Lower Incisors.—When the carious cavity is large and situated on the proximate surface of the inferior incisor, the pulp-chamber is opened from the cavity, as heretofore directed for the upper teeth; but when the cavity is small, the opening is better to be made at the lingual surface. From the latter position the cavity of the fang is very easily prepared and filled. This opening should be made very small.

Lower Cuspid.—For the inferior cuspid it is generally better to open into the pulp-chamber from the carious cavity in all cases, because the additional opening, which it is necessary to make rather large, tends to weaken this tooth.

The Lower Bicuspid.—When a case is on the right side and presents a distal exposure of the pulp, the best channel of approach usually is through the buccal parietes of the tooth. The situation of the opening should be a little above the gum. The direction should be obliquely downward (Fig. 125). The angle produced by the relation of the line of the opening to the pulp-chamber is cut away by any convenient means, as above described for the central incisor. When the case is on the left side, there generally is not any difficulty in opening from a distal cavity. If this is found impracticable, the tooth should be drilled on the buccal aspect, as

FIG. 125.

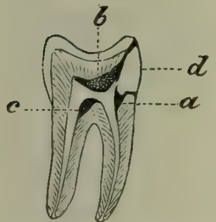


above described. When the carious cavity is on the mesial surface, the preparation of the pulp-chamber is best made from it in the usual manner.

The Inferior Molars.—The difficulties of preparing the entrances to the fangs of the inferior molars are greater than of the other teeth, and therefore more complete directions should be given. These teeth are more subject to alveolar abscesses than any other class, which may be due to the greater complication of this branch of the treatment as applied to these teeth, or to the fact that filling the anterior fang is more difficult because of its flat form; and if imperfectly filled, gravitation favors the retention of the septic matter in immediate proximity to the peridental membrane. Whenever untoward conditions eventuate in an abscess, the treatment of this lesion is less certain of successful issue, probably in consequence of the fact that the discharges of the fistula have to rise against gravitation. These relations require that greater caution be pursued during the whole course of the treatment.

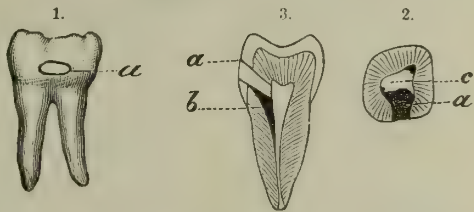
Where the cavity is in the mesial surface of the tooth, the opening into the pulp-chamber should be made from this aspect, and considerable cutting is frequently required. It is necessary not only to make increase in the size of the pulp-chamber to give access to the anterior root-canal, but the dependent portion of the roof of the pulp-chamber must be channelled out to enable the posterior root to be reached. In addition, a portion of the floor of the chamber should be cut away to remove the abrupt angle at the orifice of this fang. These three described sections are shown in Fig. 126 at *a*, *b*, *c*, *d*.

FIG. 126.



Anterior Pulp-exposure of Inferior Molar.

FIG. 127.



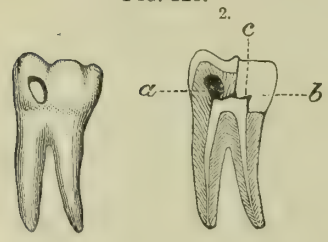
When the cavity is situated in the coronal portion of the tooth, the freest cutting should be made, to include the whole of the roof of the chamber, as described for the upper molar. When, however, the coronal cavity is a small one, but exposing the pulp-chamber, or when the pulp has become devitalized without exposure, a far better course of approach is through the buccal side of the tooth. This direction gives the readiest access to the pulp-chamber and fangs, and requires less cutting and consequent weakening of the tooth than any other plan which has been proposed.

This plan is represented by Fig. 127. 1, *a*, shows the position of the opening, which may be round or slightly oval, and afterward enlarged laterally on the inside, as shown at 2, until the interior dimension in the horizontal direction is as great as the width of the pulp-chamber;

3 shows the drilled opening (a) and the cutting (b) in the vertical direction to give easy access downward into the fangs.

Whenever the distal proximate cavities of the inferior molar are of moderate size, this method is also the best for the reasons above given.

Fig. 128.



When, however, the cavity is large, the canal of the distal fang may be prepared and filled from the coronal direction by cutting away the coronal plate of enamel. Access to the anterior fang is made by drilling an opening in the buccal side opposite to this root, and preparing the access in the manner previously described. Fig. 128 shows this plan. 1 represents the position of the opening to the anterior fang; 2 represents a section in an anterior posterior direction, in which a shows the manner in which the opening gives access to the anterior root; b shows the outline of the distal cavity; and c shows the direction in which the distal fang-canal is reached.

The complete method herein described for procuring access to the pulp-chambers, and for preparing the form of the pulp-chambers and orifices of the fang-canals, is substantially the same as was systematically practised by Dr. Maynard as early as 1850.[1]

The complete devitalization of the pulp should be effected before any considerable amount of the described cutting to prepare the pulp-cavities is made; but before the fang can be thoroughly cleansed and filled these procedures should be carried out in the most careful manner. It is obvious, unless direct entrance be made to the orifice of the fang-canals, that it is impossible to fill them. As has been pointed out, this is an essential element of successful treatment of pulpless teeth.

Instruments adapted to Cutting Orifices of Approach to the Pulp-canals.

The instruments for this purpose should be constructed to effect the enlargement of the orifice of the canals without roughening the sides and without mangling the surface of the canal opposite the channel. If, for instance, in making the channel of approach an ordinary drill be used, there is great liability that it will cut into the opposite side of the canal and produce a depression into which the plugging instrument will inevitably be disposed to enter. This is by every means to be avoided, since this aspect of the canal should direct the course of the plugger.

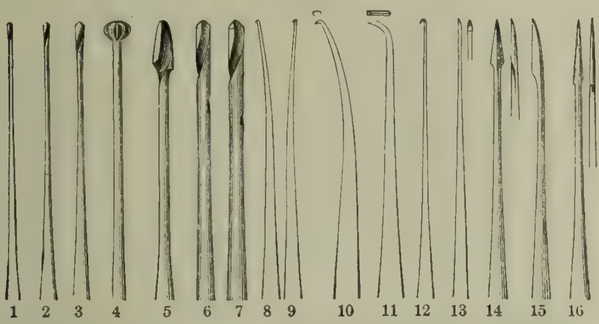
For enlarging the opening of pulp-exposures Dr. Palmer's nerve-instruments (Fig. 129) are well adapted. Nos. 1, 2, 3 are for the front teeth; Nos. 5, 6, 7, for the molars. Engine burrs of proper size and suitable form may also be used for this purpose. Nos. 14 and 16 are especially adapted to ream the orifice of the palatal roots of the upper molars and the distal fang-canals of the lower molars. Nos. 8, 9,

[1] *Dental Miscellany*, vol. i. p. 181.

10 are adapted for draw-cutting in the opened canals to cut away angular obstructions.

Much of the cutting required to prepare the channel of approach

Fig. 129.



may be done with various sizes of the gouge for groove-cutting shown at Fig. 130. These may vary in width from Nos. 14 to 18 of the gauge-plate, and, as before stated, the round burr may be used by a withdrawing movement if it can be withheld from cutting the farther side of the enamel.

Fig. 130.

The form of the opening to enable the fangs to be reached throughout their extent having been shown, it remains to describe the method of securely closing the canals of the fang. It is obvious that the delineated shape given to the different pulp-chambers enables this procedure to be effected.

When to Fill the Fang-canals.—The question now arises as to the best period to fill the canals. This, it may be stated, depends upon the condition of the peridental membrane. If there has not been any disturbance of this structure during the process of devitalization, and the pulp has been removed entire and without hemorrhage, there appears to be no reason why the fangs may not be closed at once, since the dangers lie altogether in the possibilities of any effusion which may take place into the canal becoming putrescent and rendering liable some infection of the investing membrane. Therefore, if the indications favor a healthful state of the parts, nothing is to be gained by delay. This method is borne out by the practice of a great proportion of intelligent dentists, and is apparently founded on correct principles and supported by the results of experience.

When, however, there are evidences of disturbed conditions at the end of the fang, delay becomes necessary, and the effort must be directed to allay the excitement. This requires the application to the gum of a medicament possessing counter-irritating, sedative, and discutient properties. At the same time, the fang-canals require to be dressed with an antiseptic, as before described. These dressings should be made every few days, and at all times the external cavity should be hermetically sealed to exclude septic influences and prevent the entrance of foreign matter.

Whenever practicable an antiseptic thread of cotton should be carried

to the end of the canal, to effect drainage of the serum or lymph which may enter through the foramen.

If the disturbances have not been caused by the absorption of any portion of the arsenic, and are simply the result of the irritation of the pulp by the destroying agent, the excitement at the end of the fang should pass away in a few days, when the canal may be promptly sealed at the apex.

Should the disturbance increase, it should be treated as directed in the section on disturbances following the death of the pulp.

Filling the Pulp-canals.—The nature of the material with which the fang-canals of teeth should be filled has been subject to various widely differing recommendations. Even the principles governing the treatment of this subject have been open to great differences, some maintaining that the fang should be filled solidly and permanently with gold or any fixed material; others, that the filling should be of such a nature that it can be removed at any time should disturbance arise. The former plan is based on the principle that healthy conditions of the tissues at the end of the fang being established, there is little danger of inflammation afterward occurring, and that if it should happen the treatment should be external and on general principles. Inflammatory conditions are not likely to arise unless some defect exists, such as a space at the end of the fang-canal or the presence there of some pervious substance, that at length becomes saturated with secretions which become putrescent and acquire irritating properties.

If this argument be correct, the means which will enable the fang to be filled to the end by an impervious substance is a correct procedure. In this place the means of filling with gold and tin alone are under consideration.

There are three methods by which these materials are introduced—viz. 1st, by wrapping a few layers of foil upon a broach, which is carried by the broach to the end of the fang and is packed there; 2d, by rolling the gold into little cone-shaped cylinders, which are packed into the end of the fang; 3d, by carrying to the end of the fang strips of heavy gold and packing them with suitable instruments. Of the three methods, the first one is best adapted to small canals, the second and third to larger ones.

The method of conveying the gold on the broach is an admirable adaptation of the means to the end. It was long practised by Dr. Townsend. A ribbon of gold composed of a half sheet of No. 4 or 5 is folded twice and cut into square mats. These are about one-third of an inch in dimension. One of these pieces is laid upon the left index-finger, and is rolled upon a tempered Swiss broach in such a manner that the broach is applied on a line with the hypothenuse, but does not quite extend to the angle. When the foil is rolled upon the broach the wrapping of gold is loosened upon it by slightly withdrawing the broach, and, as there is some gold beyond the point of the broach, it may be conveyed to the end of the canal with little danger of the broach passing through the foil. Concurrently with this movement the gold is pushed off with a small fang-plugger, and may then be forced downward and be malleted firmly into place.

The cones of gold for the larger roots may be made in the same manner, but of larger size, and may be put into the fang with pliers and malleted into place. The plugging instruments with which the cones are pressed downward should be large enough to nearly fill the fang, to enable them to convey the gold before them; after each piece is placed a smaller instrument is selected, when the gold should be malleted solidly into the apex. By this means the ends of the roots may be more effectually sealed than by pressure, as the delicate instruments so often required will bend under pressure, when no deflection would be caused by light percussion.

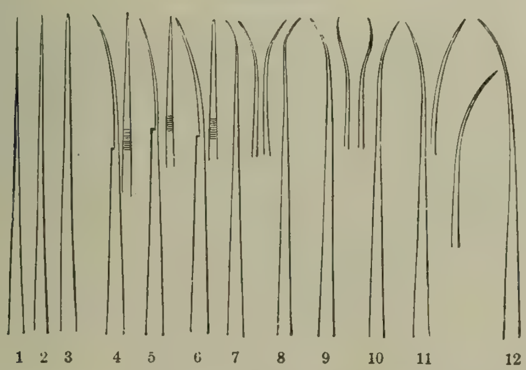
Strips of heavy gold may be conveyed to the end of the fang-canals in a similar manner, and gradually folded into place and malleted.

As regards the employment of gold for filling the fang-canals, it is not required to extend it farther than one-third of the extent, as the chief purpose is to thoroughly seal the end. The remainder is best filled with oxychloride of zinc, on account of the disinfecting influence this substance has upon the contents of the canaliculi. This substance would be preferable to any other for the whole canal if there existed reliable means to prevent a portion from being forced through the foramina. The oxychloride may be used to fill the entire pulp-chamber, except when it is necessary to use this as a basis for the retention of the exterior filling. This portion of the filling may be made serviceable to lighten the shade of discolored teeth by the reflection of light through the tooth from the surface of the oxychloride, which for this purpose should be the whitest procurable.

The instruments adapted to enable the canals to be properly filled should be capable of nearly direct action. This is indicated in the elaborate description and illustrations given for the preparation of the approaches to the pulp-canals.

The form of the ultimate point of these pluggers is of importance. The end should be cut squarely off, made smooth, and then have the end burnished by a movement of the burnisher toward the point in a

FIG. 131.



manner which "feathers" the point. This "feather" catches the gold and conveys it, but has no tendency to withdraw it. The same method

was prescribed for the preparation of broaches for a somewhat similar purpose.

Allusion has been made to the practice of placing in the end of the canal a piece of medicated lint. It will be easily seen on reflection that such a practice, while it may in some instances avert a threatened disturbance at the time of the operation, must ultimately become a source of infection when in the course of time the contained medicament becomes dissipated and the lint acquires saturation by organic fluids.

The pluggers best adapted for filling the canals are the various sizes of Dr. Hunter's pulp-canal pluggers (Fig. 131). These should be of a soft spring temper that will permit slight bending without danger of fracture, and at the same time will retain their stiffness. All instruments for this purpose should be kept properly pointed and well burnished to lessen friction.

Disturbances Following the Death of the Pulp.

After the death of the pulp by any means, whether by the use of chemical agencies, by extirpation, by accidental injuries, or by the occult causes which come under the usual designation of the spontaneous death of the pulp, considerable tendency exists to the occurrence of an inflammatory condition of that portion of the peridental membrane situated near the apex of the fang. It may indeed be stated that this membrane has an unusual tendency to become the seat of ulcerative inflammation. This may have its origin in a variety of causes. Some of these have in the previous section been intimated as liable to arise out of the derangements of the pulp which have been in existence previously to its devitalization, and to the excitement which may attend the process of destruction. The explanation for this is founded on the common principle that tissues which have suffered from congestive conditions are liable to become inflamed under the influence of slight exciting causes, and, having had their tone impaired by the previous interferences of nutrition, they therefore more quickly enter into a state of ulceration.

Other causes, acting either independently or concurrently with these, are of a different nature. The original and latent conditions may be increased in intensity by the force of the causes of irritation about to be stated.

These additional causes of disturbance appear to have their origin in two general conditions:

a. In the altered relations of the parts, by which a deep-seated structure becomes exposed to external influences; and,

b. In the nature of the irritating influences which may impress this membrane.

The importance of the first-named condition (*a*) has been regarded in general surgery as of the profoundest weight, and it can scarcely be less so in any consideration of the treatment of the various excitements and serious disorders which follow the death of the pulp. This condition of the exposure of the peridental membrane to external irritants is insep-

arably connected with the second one (*b*). It is generally considered, in the modern treatment of similar exposures of subcutaneous parts, that the peculiar state which sets in is in some manner directly connected with the presence of minute forms of life that are inimical to normal functions. These have entrance along with the air or in fluids which have had contact with the atmosphere. Hence if it is desired to avoid septic influences the air or the fluids are sterilized or are charged with antiseptic substances. The implements also are disinfected before use. If it is of importance to subcutaneously perform many operations in surgery, to make exposures of the deeper tissues as short as possible, and to accompany them by antiseptic applications, it is equally necessary here.

The peculiar causes of inflammation at the end of the fangs of the teeth derive their chief force from the morbid influence occasioned by the presence of putrescent matter, which forms the nidus and becomes the habitat of septic germs. The most distressing disorders appear to have their origin in this condition, and their treatment is frequently of a very embarrassing nature and of uncertain result.

The force of these principles is frequently impressed by the peculiar conditions which are observed to be connected with the disturbed states of the peridental membrane.

The degree of the excitement is somewhat dependent upon the amount of putrescent matter, the size of the foramina, and the relation of the carious cavity to the force of mastication. Thus, when the fang-canal is small and the foramen minute the occurrence of disturbance is much less frequent than when it is larger. Thus, when the pulp-cavity is small the amount of morbid matter produced by the decomposition of the fine shreds of the pulp must be trifling, and besides, the death of the pulp to its extremity is delayed; but when the pulp-cavity and fangs are large, the death to the apex is usually completed at once when the amount of morbid matter is considerable. The opportunity also, in many instances, exists for organic matter to enter the larger roots, which tends to maintain these morbific conditions.

The situation of the carious cavity and its relations to the line of force of mastication have considerable qualifying influence. Thus, when the cavity is situated on the crown or a funnel-shaped opening exists between two molars, the food and fluid matters may be forced into the pulp-chamber, and, what is of more consequence, the morbid fluids of the pulp-chamber may be injected against the investing membrane; and also, as shall presently be shown, the form of the canal of the fang tends to cause the morbific matter generated in the pulp-chamber to be conveyed to the smallest part if no exudation is taking place to disperse it.

Teeth in which the pulps are dead are divisible into four classes:

I. Those which are in a healthy condition;

II. Those which are in such a state that slight causes of irritation may excite peridental inflammation;

III. Those of which the peridental membrane is inflamed;

IV. Those which have been the subject of alveolar abscess, and which are discharging through a fistulous opening.

I. Those which are in a Healthy Condition.

These may be subdivided into—*a*, those where the pulp-chamber is closed; and *b*, those where the pulp-cavity is more or less open.

a. Those where the pulp-chamber is closed.—Teeth will occasionally be met with where there appear evidences that the pulp has been dead for many years while no indications of disturbance are presented. These cases frequently occur to perfectly sound teeth when the causes of devitalization are occult, the patient not having observed any particular symptoms of disturbance, and not being able to fix any specific cause or time when the change may have taken place. Sometimes the death of the pulp in these instances is the result of slight injuries to the tooth, such as its being struck by some simple instrument or even by the blow of an infant's or a playfellow's head.

In some cases death of the pulp follows a considerable train of neuralgic symptoms which are traceable to the tooth, and which have their origin in nutritive alterations of the pulp ending in its quiet death. Oftener, violent blows may lead to more pronounced evidences of the cause of death. The latter injuries, when observed, if they have not been of such a degree as to lacerate the apical cord, are amenable to immediate treatment. A case is reported[1] where a lad suffered an accidental recoil of his gun upon his front teeth, and had one of the centrals so affected that it at first appeared of a pinkish shade. The gum was treated with aconite and the fractured surface with carbolic acid. Some weeks afterward the tooth became a darker shade of color than the other, when the pulp was supposed to have succumbed. At length, however, the proximate surface became carious, and on treatment exhibited extreme sensibility.

Similar conditions sometimes arise during the treatment of irregularities. In consequence of the continued disturbance of the peridental membrane the circulation of the pulp becomes interfered with. In these cases the first manifestation is a change in the color of the tooth, it becoming of a somewhat darker shade than the other teeth and having a dull aspect. This condition, if not relieved by rest and treatment, is liable to eventuate in the death of the pulp.

This peculiar appearance of the teeth may be observed to a less degree in many cases in which there are either pulp-disturbances or there is an inflamed condition of the investing membrane It is frequently observed in cases of congested pulps at that moment of stasis when the tooth has lost its impressibility to cold, while it still retains it to heat and to contact with the pulp. It should be regarded as a significant sign of warning.

The pulp may be found dead beneath fillings where the evidence exists that it has at last without much excitement succumbed to frequent thermal impressions. It may also after many months or years be discovered to be dead after some escharotic substance has been applied to the dentine, when the necessary precautions to protect the deeper parts of the cavity have not been taken. In these instances the indications frequently are that long-continued, slowly-progressive alterations have occurred to some of the elements of the pulp-tissue in a manner not as yet fully investigated.

[1] See *Transactions of Pennsylvania State Dental Society* for 1878, p. 53.

On opening these cases, notwithstanding the healthy condition of the tooth, the greatest caution is required. Although there is not, apparently, in some cases, any residuum of the pulp remaining, there is none the less care required to prevent the occurrence of decided symptoms, as the morbific matter present may be of the most poisonous character, and is liable to be roused into a state of great activity on the admission of air.

The case should be partially opened and immediately disinfected. For this purpose no substance exerts so much power or is as convenient as permanganate of potash. A minute crystal should be inserted in the opening and permitted to dissolve in the fluids found there, or, if the chamber is dry, a drop of water may be added. In a few moments the opening may be increased, when a solution of the permanganate may be carefully introduced on a thin layer of cotton upon a fine broach. At length, step by step, according to the indications furnished by the decoloration of the permanganate, the canal of the fang may be thoroughly disinfected and cleansed. For the same purpose of oxidizing the contents of the pulp-chamber and fang-canals peroxide of hydrogen may also be used. It should be continued as long as the evolution of gases takes place. By this careful method disturbance may usually be avoided; but if, on the contrary, a large drill be used or coarse instruments be inserted into the débris of the canal, certain well-marked excitements, as a consequence of the injection into the apical tissues of a minute portion of the septic poison held in the canal, are liable to be produced. It is a well-established fact that these apparently innocent pulp-cases are liable to run into the most pronounced alveolar abscesses. For the preliminary treatment of the condition just described, Dr. E. C. Kirk employs and advocates the use of sodium carbonate (Na_2CO_3). The method pursued by him is to wash out the cavity with hot water, to remove the coarser carious matter, to open the pulp-chamber, and, without disturbing the dead tissue, to fill the chamber with the soda in a coarsely-divided state. This is hermetically sealed, and is kept closed for from two to four days. At the end of this time the cavity is cleansed of the organic matter, which has become dissolved by the caustic action of the soda, when the roots and the pulp-chamber are filled.[1]

It should be noted that the means of security from disturbances of this character in these cases is to be found in the use of disinfectants alone, and not, as so often is attempted, by the application of antiseptic substances, as it should be kept in view that the condition causing such profound and serious disturbances is the presence of a subtle morbific poison in the remains of the pulp, which, however small in quantity, is sufficient if injected into the tissues to kindle conditions not easily subdued.

The surgical and the mechanical treatment when no caries exists are precisely the same as indicated in cases of severe and fatal congestion of the pulp, already treated of. The approaches to the pulp-chamber and the channels to give easy access to the root-canals are also prepared, as has been described in a previous section. The canal of the fang should be filled with antiseptic cotton, and the pulp-chamber and exter-

[1] *Dental Cosmos*, vol. xxvi. p. 189.

nal cavity closed to the entrance of air and moisture. After some days the case may be opened, and if found in a satisfactory condition, with the cotton dry or nearly so, and no evidence of the presence of pus, the canals and the pulp-cavity should be filled as soon as possible.

When there is much discoloration of the tooth which pertains to the dentine, as much of this should be cut out at a subsequent sitting as will not weaken the tooth. When the filling of gold is inserted the tooth will be lightened in color.

b. Those where the pulp-chamber is more or less open.—Cases of this character, belonging to Class I., are found pertaining only to persons of unusually sound constitution and of good health. On opening any given case when there has existed an external aperture into the pulp-chamber, the same caution is necessary as has been above enjoined in reference to closed cases. While the conditions are not so prolific of danger of immediately violently poisoning the peridental tissues, there is nearly the same liability of exciting disturbance by incautious procedures.

The treatment should not vary from that previously given, excepting that the pulp-chamber should be loosely filled, and when the case is closed it should have more immediate supervision in consequence of the possibility of some overlooked effusion from the tissues at the end of the fang. Here it is well to be on the strictest guard, and, as the case has been open to the influences of the fluids of the mouth, it is not required to immediately make an entire closure of the cavity. The enlarged opening into the pulp-chamber should be constricted to prevent the fullest access of external influences, and slight communication should be continued until the tests have satisfactorily determined that no effusions are taking place into the canal.

II. Those which are in such a State that Slight Cause of Irritation will excite Peridental Inflammation.

These may be subdivided as follows:

a. Cases in which the death of the pulp has resulted as a consequence of congestion or injury;

b. Those in which the pulp-chamber has been continuously open for an indefinite period.

a. It has been shown during the consideration of the congestion of the pulp that one of the accompanying conditions is a somewhat disturbed state of the circulation of the peridental membrane at the apex of the fang. The blood-vessels are enlarged; the nerves of the part are in a state of exalted sensibility; and in some cases there is even some lymphatic infiltration of the tissues of the membrane. These symptoms usually somewhat subside for a short time, varied by the constitutional tendency and the amount of the previous disturbance.

The above conditions are liable to be secondarily renewed with more marked characteristics, to which the preliminary disturbance predisposes. They arise at the moment of commencing putrefaction, and may possibly be exaggerated by the existence of bacteria in some remains of the carious matter at the bottom of the cavity. The fact that two congestions may occur in the same mouth at near periods, followed by death of the pulps, of which one case may be benign and the other

accompanied by considerable excitement, would point to the presence of some sporadic cause in the one which may have been absent in the other.

These secondary disturbances do not usually happen, however, unless the congestion has taken place in a tooth in which the pulp-chamber is closed, as when the tooth has been filled over an exposed pulp or where attempted conservative treatment of the pulp has failed. The indication for treatment under this head is to open and remove the dead pulp at the earliest possible moment, and next to disinfect the canal of the fang and close it temporarily with a mild antiseptic. At the same time, some treatment should be directed to make a favorable impression upon the peridental membrane. This will consist in stimulation of the gum by means of capsicum plasters or the application of iodine and aconite in combination with chloroform.

An important consideration connected with the treatment of the canal of the fang in these cases is that it should always be carefully dressed with aseptic lint, and that external moisture be not admitted. It follows as an obvious conclusion in all cases where no discharge from the tissues external to the tooth exists that to protect the peridental membrane from septic influences no external opening should be permitted to exist between the sittings.

b. When the pulp-chamber has been continuously open for any length of time it must be admitted, as a fundamental conclusion, that there exists one or more of several conditions. Either there has existed some disturbance of the membrane at the end of the root, which is a predisposing cause to its recurrence, that enlargement of the vessels exists in a latent or unobserved condition, or that there may be effusion of lymph or discharges of pus from the tissues at the end of the fang not attended by acute inflammation of the membrane. Whatever the existing condition, it may be laid down as a probability that slight effusion of secretions through the foramen into the canal is taking place, and the treatment must be carefully conducted in agreement with the danger of damming up these fluids. The perils arising from the presence of effusions within the canal spring from their tendency to undergo putrefactive changes, as well as from the fact that their accumulation produces painful distension of the tissues at the apex of the fang.

The etiology of some of these conditions was defined in the consideration of disturbances of the pulp, when it was shown that the pulp in many instances undergoes obliteration by a process of ulceration, which point of ulceration may at length be found at the outlet of the foramen. The effusion, however, may be simply the natural escape of lymph from the hyperæmic vessels at the apex of the root.

It does not appear to have heretofore entered into the discussion of this subject that free escape of effusions into the larger part of the pulp-canal is avoided by capillary action, or that the tendency of capillary attraction is to induce some effusion from the apical tissues into the smaller end of the canal, and that the same force tends to maintain the effused product there, because this is the smallest part of the tube. This phenomenon is constantly observed when the amount of effusion

is not sufficient to produce a current through the canal. The significance of this effect will appear in the sequel. It is frequently observed that when complete removal of the pulp-contents has taken place from the smaller pulp-canals they are more difficult to perfectly dry than the larger ones, such as those of the central incisors or those in the palatal roots of the upper molar. Thus, the drying of the bicuspid canals generally requires more frequently repeated application of the usual means than do those before mentioned.

The amount of these secretions varies considerably, sometimes being infinitesimal, in other instances being so copious as to rapidly fill the pulp-chamber and escape out of the external cavity. Occasionally these free discharges are accompanied by distinct pulsations. Their character is equally various, as they may be of serum, of lymph, or of pus in small amounts.

As stated before, the fundamental element of the treatment consists in preventing the engorgement of the canal and the infiltration or distension of the tissue at the end of the fang; but the essential feature of the treatment is the restoration of a healthy state of the peridental membrane. These two ends may be secured by perfectly cleansing the pulp-canals, and restricting the outlet to a size estimated to be sufficient to carry away the escaping fluids. At the same time, attention must be given to aseptic drainage combined with stimulant applications to the gum. The most important means to pursue in these conditions is perfect cleanliness of the pulp-chamber and canals; and for the securing of this object the case should be repeatedly opened, disinfected, antiseptically treated, and closed again. At each dressing the external opening may be reduced in size until, after a few times, the opening may be entirely dispensed with.

When it is found prudent to close the tooth against the admission of air the canal should be filled loosely to the end, and the external cavity closed with a gutta-percha stopping. If after a few days the case remains comfortable, the canal may be filled to the end with a waxed thread. If the cavity has been properly prepared, as previously directed, the thread may be carried down to the end of the fang, and may be packed very quickly with sufficient care. The purpose of this is to test the case. The external cavity is then hermetically sealed. The intent of this procedure is to make sure that the conditions will permit the permanent filling of the canal. In a few days this may be done if no disturbances arise.

When there is no indication of the occurrence of effusion the foregoing precautions, except the later-described ones, are unnecessary. There are occasional cases, however, when, notwithstanding the absence of effusion, the tooth will not tolerate hermetic closure. In these cases the usual diagnosis is that gases are escaping directly from the tissues and have been seeking this outlet. When this appears to be the case, the treatment should be as above described, with the substitution of pellets of varnished cotton for gutta-percha. This dressing, while it excludes moisture, will permit gaseous exudations to pass through it.

The too common practice in the class of cases under consideration, of exhibiting strong dressings of carbolic acid, chloride of zinc, and

other irritating drugs, cannot be to strongly condemned. Their use generally increases the tendency to inflammation of the tissues, and arouses latent conditions into those of active disturbance. The slight escape of serum or lymph from the tissues at the end of the fang are generally salutary, and will continue until the conditions which underlie the discharge have been remedied. How serious, then, must be the administration of powerful medications in conditions where natural processes, combined with cleanliness and mild disinfectants, are likely to be sufficient!

III. Those of which the Peridental Membrane is in an Inflamed State.

The indication of the arrival of this state is marked, and in the early stages consists of simple soreness of the tooth to contact of the other teeth or of foreign substances, and quite soon, if relief be not afforded, the determination of blood to the part produces rapid changes in the surrounding tissues, when infiltration of the adjacent structures by lymph may occur, accompanied by external swelling of the face. These developments are of varying degrees of intensity. But their course, if unchecked, leads to the formation of an alveolar abscess. The most general cause of this train of disorders is as previously indicated—either the irritating influence of some morbific matter, the occlusion of the pulp-chamber, which prevents the escape of otherwise innocent effusions from the end of the root, or an unusual tendency to purulent inflammation.

In addition to the treatment laid down in Class II., counter-irritation and stimulation of the gum, combined with applications of iodine and aconite, are indicated. These may be employed singly or at the same time according to the urgency of the presented disturbances. When both counter-irritation and the use of iodine are decided upon at the same visit, one should be applied to the outer surface of the gum and the other to the inner aspect. The most useful means to produce counter-irritation is by a small mustard plaster constructed like the capsicum plasters, which are also useful for stimulating the tissues. The chief reliance, however, is to be placed in the use of iodine. This should be combined with aconite, as follows:

℞. Tinct. iodi, f℥ij;
Tinct. aconiti, f℥ij;
Chloroformi, f℥j. M.

This should be applied to the gum, after cleansing it of mucus and drying the surface, by means of a camel's-hair pencil or by a pledget of cotton. When the latter method is employed, the excess of the medicament should be pressed out to confine its action to the neighborhood of the part affected.

It is obvious that the therapeutic treatment will be of no avail unless the assigned causes of the inflammatory condition are removed as previously directed. The purpose of the therapeutic action is to check the course of the inflammatory process and to induce resolution.

Both the surgical and the therapeutic treatment may have to be

repeated for several days to secure control of the conditions. When they are subdued, the treatment to be continued has already been indicated in the consideration of Class II.

There are occasions, where sudden attacks of inflammation or infiltration of the tissues takes place, when no communication can be established with the parts at the outer end of the fang. The foramen may be occluded in some manner, so that the finest broach cannot be passed. When this condition exists decided action generally becomes necessary, because the absence of usual drainage renders nugatory any prospect of resolution taking place. There are two courses to be pursued—to drill through the apical foramen of the affected root, in order to evacuate the accumulated secretions and to effect some depletion of the parts, or to make an opening through the external tissues opposite to the end of the fang.

In pursuing the former course it is important that the drilled opening be very small, and that it be done with instruments which will follow the course of the canal, and not pass out at one side of the apex. Sometimes the watchmaker's broach may be used as a reamer to enlarge the opening. If drills become necessary, the smaller Hopkins four-sided reamer answers well. The reason for avoiding a greatly enlarged opening is to limit the exposure of the tissues around the apex and to lessen the risks of the subsequent closure.

When an opening is made through the gum and alveolus certain careful precautions are necessary. As under the circumstances requiring this procedure the gum may be in a painful condition, it should be made insensitive. This may be effected by ether or by rhigolene spray. The position and direction of the opening must be carefully calculated to terminate it at a point close to the apex of the fang. The size of the instrument should be small, and it may be formed by sharpening to a wedge-shaped point a fissure drill. At the moment of making the entrance an incision should be made through the gum to the bone; if the gum is then held aside in two directions, the drill may be rapidly passed to the destination. The operation should be nearly painless.

There are certain circumstances where this method is followed by the happiest results—where, for instance, a fang apparently well and having undergone the tests is filled, when suddenly a development of threatening symptoms occurs, or where immediately after the insertion of a pivot tooth, although all the usual precautions have been taken, the same unexpected result happens. The effect of the treatment appears magical in comparison with the slow process of subduing the septic disturbances which may have been going on in such cases. The bleeding effects thorough drainage, and the character of the traumatic injury induces the formation of plastic elements.

At the same time, this operation should not be performed without every care being taken and after thoughtful consideration. There are conditions and circumstances where such an interference, instead of proving beneficial, might lead to serious consequences; such, for instance, as a low condition of the patient conjoined with a decided tendency to septic irritation. It should be kept in view that as the drilled opening is into a bone, the result of the operation has some of the elements of a

compound fracture. For this reason it should be confined to cases which promise to be of a curative nature, and should be restricted to the requirements of a subcutaneous incision so far as this be possible.

The differences between an opening of this character and an established fistula for the escape of pus from the parts near the end of a fang are very marked. The latter has its track through the bone bounded by a limiting line of soft tissue, which protects the cancellated structure of the alveolus from infiltration.

Sometimes some ecchymosis of the face adjacent to the injury takes place: this is not of a serious nature, but it is a warning of what might occur in case such an opening were made into a septic abscess.

IV. Those which have been subject to Alveolar Abscess, and which are Discharging through a Fistulous Opening.

The most common result of continued inflammation of the peridental membrane is the occurrence of the development of a purulent condition at the apex of the roots of the teeth, accompanied by the ultimate formation of a fistula through the alveolar walls and the gum by which purulent secretions have an outlet. This condition in its etiology and pathological aspects has been fully treated elsewhere in this work. At this place it remains only to consider the course of treatment which promises to arrest the continuance of the purulent condition.

It has been pointed out that the state at the end of the fang may be one of simple ulceration, in which case the small amount of pus which is constantly being thrown off has been prevented in some manner from finding an outlet; it has accumulated at the end of the fang, and has caused distension of the tissues, which has produced some excitement and increased formation of purulent matter, which at length has established a fistulous tract. In some instances these channels are created without disturbance and without the knowledge of the patient. In other instances, as already shown, the inflammatory process may be acute, and may involve a large area of tissue, leaving at last a fistulous tract, through which the products of the abscess are discharged. This drain usually continues so long as the inflamed state of the membrane exists or the septic excitement continues.

There are certain general considerations which should be recounted to make clear the subjoined course of treatment.

The state of the health of the patient exercises considerable influence upon the suppurative process. As danger of inflammation running into suppuration depends largely upon the absence of vigorous constitutional conditions, so the limitation of suppurative action requires in many instances the subsidence of the systemic depressions which favor the degeneration of the exudation-cells. Those familiar with the treatment of disorders at the end of the fang constantly observe how readily in some instances, under appropriate treatment, the disturbed state passes away and the suppurative process ceases, and how in other instances similar treatment is of no avail. In the latter the remedies may not be of deficient power, but the exhibition of them may be combated by impairments of the general health.

The delay of treatment of the ulcerative condition has an important qualifying influence upon the course of treatment. This permits the tissues to lose to a great degree their nutritive tone, and produces a state of chronicity which is inimical to arrest of the ulcerative process and induces an easy recurrence of the disorder after an apparent recovery.

The seat of an inflammatory condition and of the ulcer has also considerable influence upon the course of treatment. In regard to the ends of the fangs of the teeth, the position is such that perfect drainage of the secretions is not easily effected, and as the inflammation in the first instance was excited by the presence of foreign matter, so the inability to perfectly remove the suppurative products has a tendency to maintain the ulceration.

The absence of complete rest for the tooth is another factor which tends to prevent the early relief of the disturbed state. The situation of the teeth and the necessity for their frequent use, combined with the fact that teeth in this condition somewhat protrude from their sockets, and are therefore more subject to motion than the healthy teeth, make it difficult to secure for a sufficient time a state of rest.

The grade of the inflammatory condition of the part is also of importance. As long as the inflammation of any part is above the state favorable to the production of plastic exudation, the necessary result is the degeneration of the exudation-cells.

THE TREATMENT.—The treatment of this form of inflammation should on account of its peculiarities be largely of a local character. Whatever constitutional treatment may be appropriate consists in the application of such hygienic measures as may promote conditions favorable to nutritive tone.

Local Treatment.—This requires three considerations: Firstly, to remove the cause; secondly, to maintain thorough drainage; thirdly, to lessen the grade of the existing inflammation.

Firstly, removal of the cause is attained by the cleansing of the pulp-chamber throughout its whole extent.

Secondly, the maintenance of drainage requires more than usual care. It has been shown that the force of capillary attraction tends to retain the secretions at the smallest part of the pulp-canals; to counteract this tendency the drainage-threads should be conveyed to the end of the canal. This is best effected by means of a spring-tempered broach of suitable size. The end should be cut transversely and feathered, as directed for packing gold in the fang-canals; a barb or two may also be cut in the broach, pointing toward the end of the instrument. The ordinary fine canal-fillers may be used for this purpose when prepared in the manner above directed.

The most serviceable substance to use for drainage is fine flax thread. This has the advantages over cotton fibres in that it can be carried with much less difficulty, and may be completely removed by grasping the end which is permitted to extend into the pulp-chamber. The same kind of thread is also adapted for test-filling of the canal of the fang; for this purpose the fibres are filled with wax. Antiseptic and disinfecting dressings may also be applied by the above means.

In connection with drainage the irrigation of the track of the fistula is an important means of securing the removal of the secretions and of making therapeutic applications. To aid this, communication through the end of the fang should be established by slightly increasing the size of the foramen when this is too small.

In many cases, when the treatment is favored by vigorous systemic conditions, little more is required than the simple cleanliness of the track, combined with good drainage. As gravitation in the upper teeth favors the drainage of the fistula by natural means, this simple treatment is more easily conducted than when the lower teeth are involved. The effect of gravitation is to retain the purulent secretions in the neighborhood of the inflamed part; for this reason the treatment of these teeth is likely to be less successful. There is also some tendency to burrowing of the pus in this situation. This danger more particularly pertains to the wisdom teeth, from disease of which there have not infrequently occurred serious cases of extensive infiltration of the tissues at the base of the tongue by the purulent products of inflammation, this having in some instances been the cause of death.

Thirdly. After the acute symptoms have passed away there may remain a continuance of a subacute or chronic inflammation which prevents the occurrence of plastic repair of the lost structures and the absorption of the exudate which has infiltrated the tissues. To promote recovery by reducing the grade of the unfavorable condition, stimulating and astringent medication should be employed during the irrigation. To these may be added, with marked benefit, any of the simpler antiseptics. Water to which is added a few drops of capsicum and oil of cajeput is generally an efficacious wash. An aqueous solution of quinia alone, on account of its tonic and its antiseptic power, is often of service. This latter remedy is claimed to have the power to retard the degeneration of the corpuscular elements of the tissues, and therefore to arrest the formation of purulent secretions.

In cases of copious and persistent suppuration no remedy appears to have so much control of these conditions as chloride of zinc. A solution of this forced through the track is frequently followed by an immediate suspension of the discharges. It is a remedy requiring cautious administration, as, if employed of too great strength, it may cause disorganization of the tissues with which it may come into contact. The proper strength is not over grains x to ℥j of water. In many instances grains v are followed by marked improvement. In combination with topical remedies to the suppurative track, tincture of iodine may be applied to the gum as a resorbent.

In this place attention should be called to the therapeutic properties of iodoform: it is particularly applicable in that form of abscess which has no exterior communication. This occurs when the amount of pus has been small and has found exit through the fang. It is more especially useful in painful ulcers at the end of the fang. It is thought to act not only as a local anæsthetic and as a resorbent of effused secretions, but also as a stimulant of nutrition.

The summary of the required therapeutics to relieve the disturbed state of the inflamed area is such a selection and combination as may

reduce the calibre of the vessels and stimulate a higher nutritive condition of the tissues, combined with a judicious employment of antiseptics.

Treatment of the Teeth of Children.

The Deciduous Teeth.—Systematic and careful treatment of the deciduous teeth is a subject which rarely receives the attention which its importance requires.

Between the ignorance of the guardians of the child and the want of appreciation of the value of the first teeth to the comfort and health of the child by both parents and the dental adviser, much injury and suffering are needlessly permitted. These teeth are for service during one of the most important periods of life. It is a recognized principle in the rearing of an animal that the hygiene and food of the first months of life qualify its future development in a manner which no future management can correct. In the human this period is a more extended one, and continues through the whole stage of the period of retention of the first teeth. This being the case, the necessity for careful attention to the preservation of these teeth becomes of extreme importance.

It is frequently found that these teeth early become carious, and the seat of the carious action is more frequently in the proximate surfaces than elsewhere, and is more liable to happen in the back teeth. The consequence of this is that the child is soon prevented from properly masticating its food because of impaction of the firmer portions of the ingesta against the gum. Soon the child diminishes the force of mastication and limits the efforts of comminution to the point of comparative comfort. The result of this must be disastrous to all the nutritive processes.

The methods of filling teeth of little children, except for the timidity of the subjects, are simpler than for the permanent teeth, as they are filled either by plastic materials or by tin-foil. The preparation is also much less elaborate than for the permanent filling of the adult teeth.

The teeth are separated by cutting, and the cavities are prepared by excavators. As the pulp is very near the proximate surfaces, the greatest care is necessary to avoid wounding this organ; and for this reason the teeth of children of this age should be closely watched and the cavities opened at the earliest practicable stage of their progress.

Well-constituted amalgams and tin-foil are the most durable, and on the whole make the most satisfactory materials to use. As little children cannot employ the means to cleanse the teeth which adults use, the adjoining surfaces of fillings should be brought into contact at the risk of the recurrence of decay. If spaces are permitted to exist, they become packed with ingesta, which leads to soreness of the gums, disuse of the teeth, and early recurrence of decay.

Should the pulp become exposed, there appears to be but one course to pursue, which is to devitalize this organ. No attempt at conservative treatment ever proves of any avail. The arsenical paste should be of small quantity, and be either pricked into the tissue or the paste laid upon the dried pulp and the excess removed. One or two applications are sufficient to enable the whole pulp to be removed. Extreme caution

is necessary in using arsenic for this purpose where there is any reason to believe the process of absorption of the fangs has commenced, as serious injury might be inflicted by the diffuse action of this agent.

When the pulp is removed the pulp-cavity, and in most instances the canals, should be filled. This is required to restrict the occurrence of alveolar abscess, to which these teeth are extremely liable.

The most suitable substance with which to fill the pulp-chamber is gutta-percha, because it is the simplest to use and the least irritating when by the resorptive process this portion of the filling comes into contact with the soft tissues.

A plan advocated by many for several years, of destroying the pulp of the deciduous teeth, filling the carious cavity, and then of drilling through the outer wall of the tooth into the pulp-chamber to give outlet to any secretions which might form, cannot be too strongly reprehended. This procedure is in nearly all instances followed by alveolar abscess, accompanied by diffuse swelling and continued suppuration, in consequence of septic action being maintained by the constantly open artificial fistula through the tooth. For some not clearly seen reason the disturbances brought on by this mode of treating the deciduous teeth are more extensive than those following the same methods applied to the permanent teeth.

As the first and second deciduous molars remain in the mouth for several years after the eruption of the first permanent molar, as this molar in many cases is of an inferior character, and as many children are not fitted to have caries of this tooth properly treated, it becomes important to indicate some line of treatment of these teeth preparative to the eruption of the bicuspids near the twelfth year of life. If these teeth are of good quality, if the patient has the necessary moral force, and the deciduous teeth are not much subject to decay, there are no reasons why the first molar teeth may not be filled in a permanent manner. But if, on the contrary, the first molars are of inferior quality, the patient timid and of uncertain endurance, and the deciduous teeth much decayed, the indications favor temporary treatment to simply preserve them from destructive changes until time shall prove whether it be necessary to retain or to extract them.

Whether the first molars are to be retained depends upon a number of facts and conditions, which have to be carefully considered before so grave a step be taken as their removal.

The existence of decay of the deciduous teeth is a circumstance conveying with it the utmost uncertainty concerning the preservation of the first permanent molars, and at all events requires that temporary treatment be attempted. If in addition this indication of the activity of the exciting causes of caries be strengthened by commencing decay of the proximate surfaces of the permanent incisors, the prognosis is thereby rendered more unfavorable.

With all these conditions apparent, if the first molars be of soft structure, having large sulci, and commencing proximate caries on the anterior face, combined, as is frequently the case, with threatened irregularity of the teeth as a consequence of insufficient development, the indications point strongly to their removal. To attempt to preserve through the life

the first molars under these circumstances eventuates extremely often in the loss not only at length of these teeth, but in the permanent injury of the contiguous teeth. In consequence of the crowded state of the mouth, combined with the unpropitious functional conditions, the above result is always imminent. This argument bases the extraction of the first molars entirely upon the existing conditions, combined with those indications which point to the prolonged malaise which underlies the impaired functional disorders.

If the child has been under careful surveillance no mistake need be made, as by the time when it becomes necessary to act signs will be presented either of a returning healthful state or of progressive retrogression. There can be no greater mistake made than the indiscriminate extraction of these teeth on the general principle that because the loss of them is frequently followed by the best results, it must generally prove beneficial. The first molar, notwithstanding the statistics are against its value, is frequently the most enduring and the most firmly established tooth in the arch, and should, when these qualities are presented, be retained.

When extraction is determined upon, the question of next importance is, When shall these teeth be removed? If it be done too early, retardation of development of the whole maxilla frequently occurs; the back of the arch becomes contracted; in some instances the form of the lower jaw changes in such a manner that the forward part is curled upward and drives out in an inclined projection the upper incisors by the impingement of the inferior teeth against the inner faces of them. On the other hand, if their removal be delayed until after the twelfth or thirteenth year, the second molar soon leans forward in such a manner as to present only its posterior cusps to the upper teeth, and an unsightly triangular gap is made between it and the second bicuspid.

If the removal is effected at a period immediately preceding the eruption of the second molar, the general result is that this latter tooth moves forward without undergoing any derangement of its orderly articulation with the opposing teeth. The time when this occurs is a very variable one, in some instances the development having progressed sufficiently by the middle of the eleventh year, while in others it may be delayed until the twelfth year. The extraction of the inferior molars should precede that of the superior ones by from three to six months, to permit the upper first molar to guide the second lower one in its forward passage and to prevent the possibility of its rising too much in its socket. In this connection the fact should not be lost sight of that the inferior molar nearly always precedes the superior one by six months or more.

If the indications are clearly established in favor of extraction, and the operation be performed at the proper time and in agreement with the sequence of eruption, the second molars take their place in nearly the same relation to the bicuspids that the first molars occupied. At the same time, the teeth anterior to them have become somewhat separated by the slight retirement of the bicuspids; which movement may inure to the benefit of all of the teeth.

There are other considerations connected with the correction of irreg-

ularities, which frequently arise under conditions similar to those described, and which have to be decided on other grounds, which cannot be here discussed, that make necessary the removal of some of the bicuspids. When this is the case the first molars should generally be retained if not broken down by caries.

In reference to the other teeth, before the twelfth year has closed the proximate surfaces of the permanent ones are benefited and protected from softening by repeated polishing of these surfaces by means of tapes and pumice, followed by oxide of tin. Should cavities occur, it is better that they be filled temporarily if the circumstances are unfavorable to permanent attention.

It not infrequently is observed that superficial caries has taken place between the incisors of children, which is largely in consequence of careless cleansing of the interstices, whereby the valleys between the teeth are allowed to remain clogged with sediment. Here it is admissible to remove the decay by polishing or by cutting away the softened enamel. If this be done by opening the space on the inner side and near the gum, and careful instructions be given to maintain cleanliness, the caries may be arrested more certainly than by delaying until cavities have formed.

When caries exists in the deciduous cuspid, as it remains from the seventh until the twelfth year in proximity to the lateral, the cavity should be carefully filled, or if the caries is superficial it should be removed.

The same procedure is required in regard to the relations of the first permanent molar and the second deciduous one, but here the difficulties are greater and the chances of protecting the teeth more precarious. When caries of the first molar happens, it is generally preferable to delay permanently filling the cavity until the loss of the contiguous deciduous tooth, when the filling may be conducted with less difficulty and be properly performed.

Hygienic Care of the Teeth.

The care of the teeth required to promote their cleanliness is a duty which should be imposed upon all alike as a necessary means to their preservation. This has become more important since the newer and probably correct view of the nature of dental caries has been under discussion. While the opinion was prevalent that dental caries was dependent either upon acid reactions set up by conditions of the oral secretions or by the acid quality of the aliments, there appeared to be no escape from carious action if these conditions existed. The recent view of caries involves the presence of amylaceous matter about the teeth, as it is by the fermentation of this sediment that acid products are formed. This consideration involves greater need of personal care of the teeth than was apparent under the older hypotheses.

The patient should, when of sufficient intelligence, be informed concerning the importance of this care and the reasons for it. He should be instructed also in the proper use of the implements fitted to cleanse

the teeth. These means comprise the pick, the silk, brushes, and suitable detergent powders.

The pick is probably the means most useful to prevent interstitial decay, since it more completely removes the sediment which becomes forced into the triangular interstice near the gum by the counteraction of the tongue and cheeks. It also by its friction tends to maintain the polish of the teeth, and when it is properly used promotes the health of the gum. The material most suitable for the small angular interstices is the pigeon-quill pick, and for the large spaces of adults small wooden ones. It is obvious that the pick should be employed after each meal, and should be used in a manner not to wound the gum.

The use of waxed floss silk is to remove whatever sediment may be lodged in the capillary spaces at the parts in close contact. This should be used at least once each day, preferably at retiring, and should be drawn laterally between the teeth, instead of being simply pushed upward. Where large spaces exist tape of either linen or cotton should be rubbed between the teeth.

Fig. 132.

The uses of the brush are to remove sedimentary matters from about the teeth, to take away the partially inspissated mucus from the teeth, and to impart to them a polished surface, which becomes favorable to the easy circulation of the fluids of the mouth over and between the teeth. Apart from the acids produced in the mouth by the fermentative processes, there may exist acidulous secretions which are the results of sympathetically disturbed function of the mucous follicles as a consequence of other and more remote impairment of function of the alimentary track. Accompanying this condition the mucus loses its limpidity and becomes thickened and ropy. In this state it adheres to the teeth and the adjacent structures and favors the retention of other sedimentary matters. With thorough and frequent brushing, combined with the previously-described means, the danger of retention is diminished when the salivary secretions may either dilute or neutralize the activity of the acidulous mucus.

A further use of the brush is to stimulate by the mechanical friction the inner surface of the gums, lips, cheeks, and palate to more healthful action.

The manner of using the brush is liable to so much abuse that instruction should be constantly given. To remove lodgments from between the teeth requires that the movement of the bristles be in a direction coincident with the sides of the teeth. To do this without injuring the gums the brush should be pressed against the teeth, and while this pressure is maintained to force the bristles into the interstices rotation of the handle is made in such a manner as will pass the bristles from the gum toward the ends of the teeth. This cleanses better than any other method, and avoids any danger of injury by forcing the gum away from the necks of the teeth.

The form of the brush is an important feature, the greater portion of

those sold being unfitted for the purpose. There should be at least two—one for general purposes and one for the inner surfaces of the inferior teeth. The principal qualification a toothbrush should have is its capacity to enter the interstices of the teeth. As it should be moved in the vertical direction, it should correspond in its curves somewhat to the form of the arch. The brush (Fig. 132) called the prophylactic brush has some admirable qualities, and better fulfils the purpose than any brush in the market. It needs, however, considerable improvement before it will satisfy either professional criticism or the wants of the people. Its principal disqualification would be removed by the addition of a fourth row of bristles or an enlargement of the tufts of bristles. It is an improvement in the right direction which may lead to acceptable modifications.

The uses of powders are to assist the brush in breaking up the continuity of the film of mucus and to maintain the polished surface of the teeth. They have also important chemical as well as mechanical uses. They may contain antacids, such as calcium carbonate, potassa, or soda. They may also excite therapeutic action in disturbed states of the gum by the presence of potassium chlorate, tincture of cinchona, quinina sulphas, etc. They may also be used to lessen the activity of the bacteria by the presence of potassium permanganate or sodium borate. These and other modifications may be made to fulfil important purposes, as may be indicated.

The use of the teeth is an important means of conducing to their preservation. This acts in several ways: It induces fuller growth of the maxilla and greater density of the dental structures by the incitement to development which use imparts; it brings about more complete comminution of the food, and thus properly prepares the ingesta for the next digestive stage; it stimulates the salivary glands, not only to a greater amount of their peculiar secretions, but induces by this stimulation a normal quality of these secretions, whereby they contribute to better effect their purpose in the digestive processes; it admixes more thoroughly the oral fluids with the bolus, and tends by the friction to produce greater cleanliness.

Deficiency of use of the teeth is one of the evils of modern life, which pertains to an early age, continues by acquired habit, is favored by the feverish haste of the age, and threatens, if persisted in from generation to generation, to at length extinguish every chance for the development of fine dentures and the establishment of sound health.

While perfect cleanliness of the teeth exercises a marked influence on their prophylactic condition, there are other hygienic considerations of greater importance. It has been clearly shown that dental caries would not be possible in connection with functional equilibrium. As the departure from normal alkalinity of the oral secretions which renders decay possible is probably connected with deranged alimentary functions, any course which would restore these functions to a proper activity would be corrective of dental caries. The larger proportion of people suffer from a degree of gastric and intestinal irritation, the consequence of errors of diet and of insufficient and proper exercise. Advice in these respects may always be beneficial, and such details should

be inquired into, especially in the case of children. A common error in the life of children, particularly of the well-to-do class, is the irregularity of their hours of sleep and of meals, and also the absence of systematic exercise. In this connection also the regular use of the thorough bath is an important measure. As the skin performs a large amount of eliminatory action and excretes much effete matter, it follows as a corollary that, in case the stimulation of the bath and correct action of the skin do not take place, the functions of this surface are thrown largely upon the mucous tract.

It has been observed in several of the asylums of children coming largely from the unfortunate classes of society that the health of the inmates soon becomes much improved under the combined influence of proper regimen and correct hygienic care. The teeth of the inmates also undergo changes in the same ratio. Caries becomes less frequent, and in some instances it has been noticed that complete arrest of dental decay has taken place.

The importance of this subject, as supplementing the required surgical and mechanical treatment of the teeth, may properly be considered so great as to warrant the space given to it, and it is also a fitting theme with which to bring this article to a close.

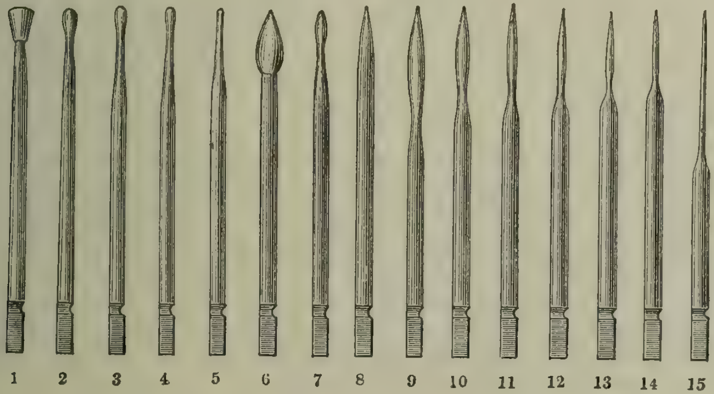
THE HERBST (GERMAN) METHOD OF FILLING TEETH.

By C. F. W. BÖDECKER, D. D. S., M. D. S. N. Y.

About seven years ago Wilhelm Herbst of Bremen, Germany, conceived the idea of introducing filling materials, such as gold, tin, and amalgam, into cavities of teeth by means of smooth engine-burnishers. The advantages claimed for this method are better adaptation to the walls of the cavity than it is possible to obtain by any other system; the saving of about one-half the time required for other methods; that some of the most difficult operations (as proximate surfaces of the molars and bicuspids) by this method are very easily manipulated; that gold can be adapted perfectly against thin walls of enamel without fracturing them; and that the introduction of gold by this method is much less annoying to the patient and less laborious to the operator.

The instruments used are mostly ordinary smooth burnishers, of which there are three sets—one set of engine-instruments, one set of straight hand-instruments, and one set of bent hand-instruments. The former two sets are designed by Herbst; the latter one, by Dr. Frank Abbott. The engine set (Fig. 133) is composed of fifteen instruments,

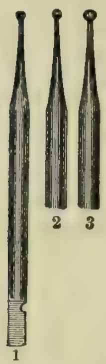
Fig. 133.



but only a few of them are very much employed, although cases are met with in which all can be used. The most important and useful of these are the roof-shaped instruments (No. 5), of which there ought

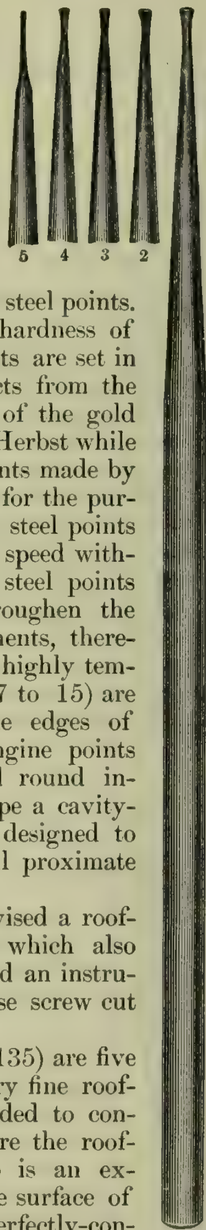
to be several sizes; they are designed to press the gold into small depressions and edges of cavities. These instruments can be made out of a broken burr as follows: The broken instrument is put in the hand-piece of the engine, and while rapidly revolving is ground upon a sheet of sand-paper No. 1. The instrument should lie obliquely, like a pen in writing, and be quickly moved, drawing it from one side of the sand-paper to the other. The instruments Nos. 2, 3, and 4, since they have been replaced by hand-instruments, are but seldom used for gold fillings. The larger instruments (Nos. 1, 2, and 6) are mostly intended for the use of amalgam and tin. The instruments Nos. 1 to 7 have of late been made of agate and bloodstone, which are preferable to steel points. The advantage of agate and bloodstone is in the hardness of these substances. Therefore, unless the agate points are set in such a manner that only the outermost part projects from the steel setting, they will break, as the condensation of the gold requires a great amount of pressure. Dr. Wilhelm Herbst while in this country exhibited some agate points made by himself, which were admirably adapted for the purpose. A great advantage of stone over steel points is that they can be run at a high rate of speed without perceptibly heating the gold, while steel points become coated with gold, and thus roughen the rotating instrument. All steel instruments, therefore, used for this method ought to be highly tempered. The pointed instruments (Nos. 7 to 15) are used for finishing and condensing the edges of proximate fillings. To this set of engine points the writer has added three very small round instruments (Fig. 134) resembling in shape a cavity-burr, but perfectly smooth. They are designed to condense gold on labial surfaces of small proximate cavities in incisors.

FIG. 134.



Mr. R. S. Williams of New York City has devised a roof-shaped condensing instrument with corrugations which also possesses some advantages. Dr. W. E. Hyde added an instrument which in shape resembles a cone with a coarse screw cut upon it, which in large cavities is very useful.

FIG. 135.

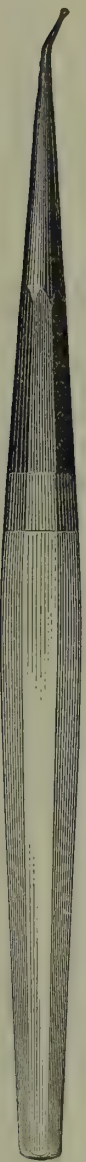


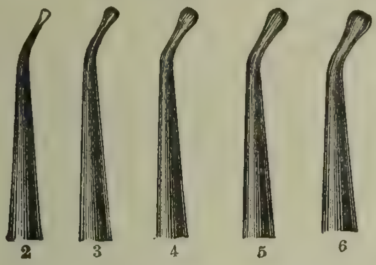
The hand-instruments designed by Herbst (Fig. 135) are five in number; four are pear-shaped, and one is a very fine roof-shaped instrument. The Nos. 1, 2, 3, 4 are intended to condense and bring the gold to its proper place before the roof-shaped engine-instruments are employed. No. 5 is an exploring-instrument which is to be pressed over the surface of the gold (especially the first layer) to discover imperfectly-condensed places. In condensing the gold the instruments are rotated in the hand about one-half or three-quarters of a turn, for it has been

observed that by a rotary motion of the instruments the gold is much better condensed than by simple pressure.

Abbott's set of six hand-instruments (Fig. 136) is intended for the same purpose as Herbst's, but they are bent. The head of the burnisher is similar to Herbst's Nos. 1, 2, 3, and 4 hand-instruments; they are in many instances preferable to Herbst's, although both will be found useful. These instruments, on account of their bend, need not be rotated in the hand, but are merely moved from one side to the other while pressing firmly against the gold. Before these hand-instruments are used they should be rubbed upon a piece of No. 1 sand-paper.

Fig. 136.





The best means to obtain some positive facts in regard to the comparative values of the different methods of filling teeth is to make experiments in a matrix of steel, glass, or in natural teeth out of the mouth; I should therefore advise every beginner with this method, before filling teeth in the mouth, to repeat some of the experiments mentioned hereafter.

With this object in view, the writer has made numerous experiments with Herbst in Bremen, and together with other able operators in this country. The most convincing experiment is the following: Take two glass tubes about an eighth of an inch in diameter, with a bore of one-sixteenth of an inch, and about half an inch in length; one end of these tubes is inserted in plaster in such a manner that the tubes extend out of the plaster about an eighth of an inch. One of these tubes is filled by the Herbst method; the other, by any other system. The result will be that the adaptation in the tube filled by the Herbst method is absolutely perfect, whereas along the walls of the tube filled by the other method there will be visible a great many imperfections. The time occupied in the procedure will be found to be invariably in favor of the Herbst method, which will be about half that necessary to obtain the best result with the others.

Other experiments of value may be made in a steel matrix which can be taken apart. This may be filled with different kinds of gold prepared in different ways. The gold should be introduced by a mallet, by hand-pressure, by Abbott's hand-instruments, by Herbst's hand-instruments, by Herbst engine-instruments of steel, by Herbst engine-instruments of agate and bloodstone, and by means of hand- and engine-instruments. The results of these experiments will be in about the following proportions:

	Weight.	Adaptation.	Time occupied.
Electric mallet	18 gr.	Imperfect.	40 min.
Hand-pressure	$13\frac{1}{4}$ "	"	18 "
Abbott's hand-instruments	$17\frac{1}{4}$ "	Nearly perfect.	8 "
Herbst's hand-instruments	$15\frac{1}{2}$ "	" "	$9\frac{1}{2}$ "
Herbst's engine-instruments, steel	$17\frac{3}{4}$ "	Absolutely perfect.	$12\frac{1}{2}$ "
Herbst's engine-instruments, agate	$16\frac{1}{2}$ "	" "	11 "
Herbst's engine-instruments, bloodstone	$15\frac{1}{4}$ "	" "	$10\frac{1}{2}$ "
Herbst's hand- and engine-instruments, agate	$18\frac{1}{16}$ "	" "	19 "

In the above experiments we observe marked differences in weight as well as in adaptation, and also in the time required for insertion, accordingly as a filling has been introduced by simple hand-pressure and the wedge system or by hand-pressure combined with rotary motion of the instrument, as will be observed by comparing experiments Nos. 2, 3, and 4. It will be noticed that the last four experiments give the same results as to adaptation, but there is a marked difference in the weight of the plugs. From which we conclude that hand-instruments followed by agate points in the engine will condense the gold much better than bloodstone, agate, or steel instruments when used alone.

One of the principal rules of filling by the Herbst method is the conversion of all complicated cavities (as proximate) possessing but one, two, or three lateral walls into simple ones (as cavities involving the grinding surfaces of molars having four lateral walls). This is accomplished by the application of a proper matrix. The matrices used for this purpose are either of steel, Brown's polishing-metal, German silver, wood, shellac; or the Jack matrix may be employed. The matrices used for the proximate surfaces of molars and bicuspids are either the Jack matrix or they may be made out of a piece of thin German silver, watch-spring, wood, or the loop matrix may be employed. The matrix mostly employed for these cavities is made in the following manner: A piece of very soft German silver of the thickness of about thirty-two (American gauge), one inch and a half in length and as wide as necessary to cover the cavity in the proximate surface of the tooth, is bent around it, bringing both ends of this metal to the buccal surface of the tooth to be filled, when by means of a pair of flat-nosed pliers the ends of the German silver strip are tightly drawn together, thereby bringing it very close all around the tooth. When this matrix fits perfectly it is very carefully removed from the tooth by the pliers, and, after the application of the soldering fluid (solution of chloride of zinc), the joint is closed with ordinary tin solder in the flame of an alcohol lamp. While soldering the flanges of the matrix it must be held together by a pair of tweezers. Great care must be exercised to have the surfaces of the German silver perfectly clean, else the tin solder will not flow well. If the space between the cavity to be filled and the next tooth is larger than the thickness of the matrix, or if the lingual or the buccal walls are broken, it will be found necessary to strengthen the matrix by adjusting and soldering a thin piece of brass wire on the outer side of the matrix, or a little tin solder may be run wherever the strength is required. This matrix, when applicable, will be found the most useful of all, but it is advisable in most instances to prepare the matrix before excavating the cavity, as in this manner the contour of the

tooth will be restored perfectly if thin walls of the tooth have to be removed during the preparation of the cavity. In cases where this plan does not answer, a matrix may be employed made out of a piece of watch-spring saw, such as may be obtained from any of the dental dépôts; a piece of the saw about half an inch long and as broad as the cavity is deep is cut off and heated over a spirit-flame until it becomes dark blue and bends around the tooth. The points of the matrix designed to rest on the cervical edge of the cavity ought to be well rounded, that in cavities extending into the neck of the tooth it may be pushed down without injuring the lingual or the buccal portion of the gum. The lateral ends of the matrix must be bent like a clasp around the lingual and buccal portion of the tooth to be filled, in such a manner that the matrix, when in position and viewed from the grinding surface, will present a semilunar form. When thus prepared, it may be secured by one or two wedges of wood, or pins may be inserted, one from the buccal, the other from the lingual, side. These wedges should be placed near the gum, between the matrix and adjoining tooth, tightly pressing the matrix against the edges of the cavity. In adjusting these matrices for mesial cavities of molars and bicuspids it ought to be observed that they do not quite reach the grinding surfaces of the tooth, else they may obstruct the entrance of these cavities. All steel matrices may be saved and used many times. When two cavities in bicuspids or molars face each other, if the former plan does not answer, the matrix, after it has been put in position, may be secured by filling one of the cavities with cotton or shellac. In cases where there is sufficient separation between the two teeth, and where applicable, the depressed Jack matrices should be used, as they restore the contour of the tooth better than any other.

In a former publication the writer mentioned that in proximate cavities of molars and bicuspids Herbst did not bevel the edges of a cavity very much, because he adjusted the matrix so closely that none of the gold had to be trimmed off; but it has since been observed by the writer that the loose adjustment of a matrix is not only no objection, but an advantage. The matrix, if adjusted loosely, will admit the gold to extend a little out of the cavity; the gold can by means of the pointed burnishers Nos. 8 to 15 be rubbed over the edges; but in these instances the introduction of the gold requires a little more care and practice.

In some cases where the lingual walls of upper front teeth are not too much broken the writer has made use of a thin piece of Brown's metal or of steel, the latter in the form of a thin watch-spring saw; but this material is in some instances difficult to adjust perfectly against the lingual walls of teeth. Brown's polishing-metal, generally used for polishing proximate surfaces, will, therefore, be found of great service. This metal is very readily bent in shape, easily adjusted and removed again. In some instances where the cavity in the lingual wall is extensive the writer has during the introduction of the gold held a small piece of thick blotting-paper under the Brown's metal, which then will stand all pressure required. For this purpose we employ a piece of thin metal (mentioned above) about an inch in length and wide enough completely to cover the cavity in the lingual surface of the tooth to be

filled. Insert it between the proximate surfaces of the incisors containing the cavity and bend one end of it, covering the cavity in the lingual surface; the other is bent out of the way, over the labial surface of the adjoining tooth, as represented in Fig. 137. When, however, in large cavities, the labial wall of a front tooth is strong enough to withstand the necessary pressure for the introduction of the gold, it should not be sacrificed, but access to the cavity should be obtained from the lingual wall of the tooth; and in this case the matrix should be reversed, as represented in Fig. 138.

Fig. 137.

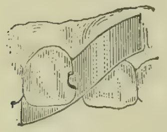
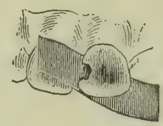
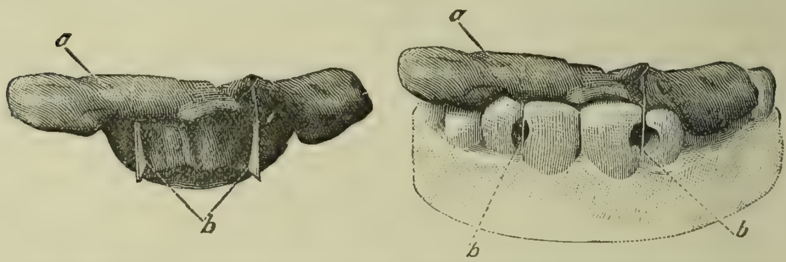


Fig. 138.



For proximate surfaces of incisors, where their lingual walls are largely broken, as well as in contour operations, a matrix of shellac is employed, which may be made in the following manner: A piece of shellac the size of a large walnut is warmed over an alcohol-lamp to the consistency of putty; after the rubber dam has been adjusted, the shellac is pressed against the lingual wall, extending a little over the cutting edges of four or six of the teeth. After it has become hard it is removed from the mouth; and if any of the shellac is pressed into the cavity, it must be carefully trimmed by cold instruments and then put back again in its place. (See Fig. 139.)

Fig. 139.



a, shellac matrix; *b*, steel spring adjusted between the proximate surfaces of the centrals and laterals.

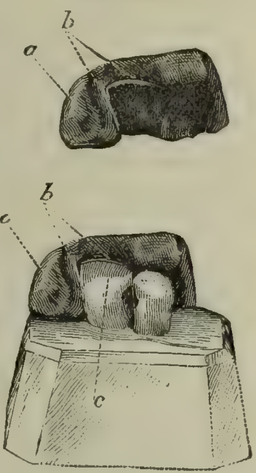
When the labial wall of a cavity is broken to such an extent that the gold can easily be packed from the labial surface, an additional steel matrix must be applied against the proximate surface of the cavity; the steel matrix, after warming, is pressed into the shellac matrix of the lingual surface, as represented on Fig. 139. This steel matrix must not quite reach to the labial surface of the tooth, as it may offer an obstruction to the introduction of the gold.

The matrices for contour operations in incisors are made similar to the foregoing, but, besides the steel matrix of the proximate surface, an additional one should be adjusted for the cutting edge of the tooth. (See Fig. 140.)

With a few exceptions, the preparation of cavities to be filled by the Herbst method is the same as for any other method, but if either the shellac or the German silver band matrix is employed, the matrix should

be fitted before the cavity is prepared. In no instance are deep under-cuts or starting-pits necessary, but the cavity should be so shaped that it will securely hold the filling; the edges are prepared in the usual manner. In a former publication the writer has mentioned that all proximate cavities of the molars and bicuspids must be made accessible from their grinding surface, but his present view is that the preparation of these cavities for this method should not differ from that employed for any other system of filling.

Fig. 140.



a, shellac matrix; *b*, steel spring fastened into the shellac; *c*, gold filled against the matrix.

The introduction of the gold is the main new feature of the Herbst method, which, if certain rules are observed, is quite simple. For this method almost any gold can be used, but the gold manufactured by Carl Wolrab of Bremen, Germany, is, on account of its softness and cohesive properties, particularly adapted to this method. The forms of gold best adapted for the Herbst method are very soft cylinders, of which the larger sizes, Nos. 0, 1, and 2 (Fig. 141), are the most useful. If foil is used, it ought to be very soft; all Nos. from 3 to 60 have been employed. The leaves are cut into 2, 4, 6, or 8 strips, according to the thickness of the foil, rolled into rope-form between the fingers or a napkin, and cut into pellets of required length, or the sheath may be divided into squares measuring from half an inch to an inch, which by means of a pair of foil-tweezers or the fingers are formed into pellets. The foil, as well as the cylinders, should never be annealed when used in the first layer of the cavity except it be a contour operation.

Fig. 141.

During the introduction of the filling material we observe a peculiar phenomenon—namely, the gold, which when unannealed apparently shows no signs of cohesion, working under the instrument as soft as tin foil, becomes, when burnished, cohesive. It is possible that electrical action during rotation exerts an influence upon it, but it is certain that Wolrab's German gold possesses the quality of becoming cohesive to a very marked degree; and it is largely owing to this that the Herbst method is crowned with success.

The main rule to be observed in starting a filling is that the first layer must be large enough, and when condensed must lie securely in the cavity without being supported by an instrument. When too little gold has been put into the first layer, or when a number of too small cylinders are used and an attempt is made to condense it, the gold will roll away under the instrument and become too hard to be again adapted to the walls and edges of the cavity. The same conditions will be observed when the first hand-instrument used in condensing the gold has been too small. After the gold has been condensed with hand-instruments the perfect adaptation is obtained by the already-described roof-shaped

instrument in the engine. This instrument, as previously stated, is to be rubbed upon a piece of sand-paper, holding it, while revolving, in about the position in which a pen is held upon the paper while writing. After the instrument is passed over the sand-paper and is perfectly clean, it is, while rotating, firmly pressed upon the gold, condensing it thoroughly into every depression of the cavity. In condensing, this instrument should not be held upon one spot, but be moved around, and especially along the edges of, the cavity. In using steel instruments care should be taken not to run the engine too fast nor to allow the burnisher while in motion to be in contact with the gold longer than from three to ten seconds, as it may heat the gold to such an extent as to cause discomfort, or even great pain, to the patient.

In some instances it is difficult to adapt the first layer of gold, especially in large or flat cavities with but small undercuts. Under these circumstances the gold may be first condensed with cotton as follows: After the necessary amount of gold has been loosely introduced into the cavity, a piece of pure cotton about as large as the cavity to be filled is pressed over the gold and thoroughly condensed, by means of a large pear-shaped engine-burnisher (Nos. 2 to 4, Fig. 133) rotating it slowly upon the cotton in every direction. When the cotton is removed it will be found that the gold lies perfectly quiet, but before another layer of gold is added, this has to be thoroughly condensed with a roof-shaped instrument (No. 5) in the engine, but without the cotton.

When the first layer of gold has been thoroughly condensed with the roof-shaped instrument, we employ the hand-instrument (No. 5), and while rotating press it tightly around the edges and depressions of the cavity. If this hand-instrument has made any deep pits in the gold, it proves that the gold in these places was not perfectly condensed, when a roof-shaped instrument in the engine, smaller than that used in the first instance, should be employed to condense these places. All deep pits present in the first layer of gold should now be filled up with very small gold cylinders and thoroughly condensed until the gold is even. The surface of a layer of gold which has been condensed by stone instruments is usually very smooth, and in most instances the adjustment of another layer of gold will be found difficult; it is therefore advisable, especially if absolute union of the several layers of gold is required, to roughen the surface of the gold by means of a hand-instrument with fresh serrations, which is best prepared from any broken excavator or plugger by tempering it hard and then breaking the point off. This instrument, while slightly rotated in the hand, should be firmly pressed over the surface, and with it the first pieces of gold should be packed, while at the same time it may be used in picking up the gold. All succeeding layers of gold are manipulated in the same manner. In some instances, as the buccal walls of molars and bicuspids, when the gold cannot be condensed by direct action of the instruments, the right-angle attachment or Abbott's hand-instruments should be employed. When a number of layers have been secured and all the walls and edges of the cavity are covered, it will sometimes be found necessary, if the operation is to be concluded by the Herbst system, slightly to warm or anneal the gold.

In some instances where it is desired to fill teeth with thin walls with amalgam we may overcome the usual discoloration of the enamel by lining the cavity with a thin layer of gold as follows: One or two of the largest gold cylinders are tightly compressed between the fingers, and when perfectly flat are dipped into a very thin solution of gum copal in sulphuric acid (about two grains of copal to half an ounce of ether). When nearly dry the gold is held before the cavity, and by means of a piece of cotton and a rotating instrument in the engine, put into position and burnished tight against the walls of the cavity. But care must be exercised that the cotton does not wind around the rotating instrument, else it may tear the gold out again. Teeth thus lined and filled with amalgam will be found not to discolor, as the gold is protected from the action of the mercury by the application of the thin copal solution.

Tin is introduced in the same manner as gold, in the form of either foil or Robinson's metal. Nos. 4 to 6 foil is cut in half, made between the fingers or a napkin into a rope, and cut into pieces of desired length, which ought to be used when prepared, as tin slightly oxidizes when in contact with the air for any length of time.

Tin as a filling material has some very desirable properties; the writer, therefore, has used a thin layer of it upon the cervical portion of every proximate cavity where it is out of sight. For this purpose the Herbst method offers great advantages, as a very thin layer of it can be burnished around the edges and walls of the cavity perfectly and with great ease.

Although the introduction of the gold is similar in almost every cavity, the writer deems it expedient to describe the method for a few typical cavities:

I. For the distal surfaces of molars and bicuspids involving the proximate and grinding surface, after the matrix has been made, the cavity prepared in the usual manner, and the rubber dam adjusted, the matrix is applied. Two, three, or four large gold cylinders are placed in the cavity by a pair of foil-tweezers; then a hand-instrument—either Herbst's or Abbott's—as large as the entrance of the cavity will admit is cleaned upon sand-paper No. 1, and with this, while rotating, the gold is firmly compressed, first into the bottom and then against the side-walls of the cavity, or in cases where the cavity is large and round the first layer may be condensed by means of cotton, as mentioned above. The gold then is thoroughly condensed, especially against the matrix and edges of the cavity, by one of the roof-shaped instruments (No. 5), and, as mentioned above, examined with the thinnest hand-instrument. In this manner layer after layer is introduced until the cavity is filled; or the last layer may be packed by the mallet.

II. The introduction of gold into cavities involving the mesial and grinding surfaces of molars and bicuspids is a little more troublesome, although, when Abbott's hand-instruments are employed, the filling of these cavities is almost as simple as those mentioned before. The anterior edges and walls of the matrix in these localities cannot always be reached by direct action; a right-angle attachment is therefore indis-

pensable, by which the roof-shaped instrument, while rotating, is firmly pressed forward against the matrix and edge of the cavity.

III. Occasionally we meet with cavities in the mesial or distal surface of bicuspids, near the gum, which, if the tooth-structure between the cavity and grinding surface is strong enough, may be filled from the buccal surface. In these instances we use as a matrix a thin piece of clock-spring about three or four inches in length and push it between the two teeth. If the cavity is situated in the distal portion of the first bicuspid, the buccal end of the steel-spring matrix is bent backward as much as possible around the second bicuspid, that it may not obstruct the entrance of the cavity, and *vice versâ* when the cavity is situated in the mesial portion of the second bicuspid. The introduction of the gold is accomplished in the usual manner.

IV. The packing of gold upon the grinding surfaces of molars is somewhat different. The first layer introduced must extend over the whole surface and be sufficiently thick to lie quietly when the instrument No. 5 is used to condense it into the several depressions of the cavity. To facilitate the packing of the succeeding layers, the hand-instrument, made out of a broken excavator or plugger (as mentioned before), should be passed over the surface, and with it the gold should be packed before the rotating instrument in the engine is employed. For condensing gold upon the grinding surfaces it is advisable to make use of agate points. When the operation is nearly completed, I would advise beginners that it be finished by the mallet.

V. Proximate surfaces of the incisors can very easily and quickly be filled by this method. The cavities are prepared in the same manner as for filling by any other system, but no deep starting-points are made; a slight rounded undercut at the cervical wall and one toward the cutting edge of the cavity are amply sufficient. The separation required for this method is not more than when the cavity has been prepared for other methods. Herbst fills all these cavities with a No. 5 instrument, but the writer has used a burnisher made exactly like a small round burr (Fig. 134), which worked very satisfactorily. When there are two cavities facing each other to be filled, a matrix made of a thin piece of clock- or watch-spring may be used to great advantage. This matrix may either be inserted into a piece of shellac, as represented in Fig. 139, or it may be used in the same manner as described above.

VI. Proximate surfaces of the incisors with broken lingual walls are comparatively easy to manipulate when a matrix is applied to the broken wall. The matrix may be made of either shellac, a piece of thin clock-spring, or Brown's metal as previously described. When the labial wall of an incisor is not broken away, the cavity may be opened and filled from the lingual surface, thus avoiding the appearance of gold on the labial surface and the annoyance and loss of time in wedging. If the teeth stand so close that they will not admit a fine finishing-strip, a small wooden wedge, or a separator must be inserted near the gum, after which the cavity is prepared and filled in the usual manner. When there are two cavities to be filled facing each other, a matrix of thin clock-spring must be inserted between the two cavities in the same manner as when they are to be filled from the

labial surface (see Fig. 139)—namely, if a cavity is situated in the mesial surface of a right upper central, the clock-spring (about an inch long and wide enough to cover the cavity) is inserted between the two centrals, when the labial portion of the spring is bent over the labial surface of the right central (the tooth to be filled), while the lingual portion of the clock-spring is bent against the lingual wall of the adjoining (left) central. (See Figs. 137 and 138.)

VII. When, however, the labial as well as the lingual walls of incisor teeth are broken to such an extent that the gold can easily be packed from the labial surface, a matrix, represented in Fig. 139—or, in some instances, the above-mentioned clock-spring matrix—may be employed. The gold is introduced in the usual manner.

Contour operations of the cutting edges of the front teeth by this method have been accomplished only within a comparatively short period; they require relatively but little time. One of the preparations sent to me by the inventor, involving the mesial, distal, and about one-sixteenth of an inch of the cutting edge of a lower incisor, required only forty minutes' time for the introduction of the gold.

The principal difficulty in these operations is the making of a proper matrix; when this has been accomplished, the filling is comparatively a simple matter. A matrix is prepared of warmed shellac (see Fig. 140), as described above. The proximate walls are enclosed by pieces of clock-spring adjusted on both sides and fastened into the shellac matrix of the lingual wall, and a third piece of clock-spring is then adjusted across the cutting edge of the tooth to be restored. When thus arranged, these matrices form a simple cavity with four side-walls, into which the gold is easily packed. The introduction of the gold is commenced first in the anchorage, without the matrix, until the gold reaches the edge of the cavity, when the matrix is replaced and the rest of the gold introduced in the usual manner, but in contour operations every piece of gold has to be carefully annealed and packed with the serrated hand-plugger under rotation before the engine-instrument is made use of. In these operations special care should be exercised to examine every layer of gold very carefully with a Herbst's hand-instrument No. 5 (Fig. 135). Every imperfect place should be filled up with the smallest cylinders, and condensed by an agate point in the engine until the surface of the gold is even, which is then roughened by the serrated hand-instrument, when it is ready to receive the next layer of gold. In this manner layer after layer is carefully introduced until the cavity is filled, when the matrix is removed and the filling finished in the usual manner.

PLASTIC MATERIALS FOR FILLING TEETH.

By A. G. BENNETT, D. D. S.

A TOOTH consists, essentially, of dentine, which surrounds the pulp and which is surrounded by the enamel and cementum. This last tissue, being but slightly connected with the operation of filling, has no direct relation to the present subject. The enamel, having but 3 per cent. of organic matter, may be considered as practically a mineral substance. It consists of rods or columns which stand at various but somewhat regular angles to the surface of the dentine.

Researches have shown that the dentine is not wholly a mineral substance, but that about one-fourth of it is organic; that this portion, having circulation and vitality, is nourished and recuperated in some degree like other vital structures; that, having nerve-filaments or fibres of living matter, it is liable to irritation and inflammation. Investigations have also proven that the lime salts, which constitute about three-fourths of the dentine and nearly all the enamel, are removed by certain acids which generally result from fermentation in the oral cavity; that the carious and softened portions of the dentine are pervaded by micro-organisms; and that when the pulp dies the organic portion of the dentine loses its vitality, and, like all animal tissue, undergoes a gradual decomposition, the final result of which is the evolution of certain gases. In these facts will be found the rationale for treatment of the dentine; this being designed to protect the exposed and sensitive surface of cavities, destroy micro-organisms, preserve the vitality of the pulp, and either prevent disintegration of the organic portion of the devitalized dentine or chemically destroy the resulting gases.

Some of the points just given, notably those respecting the vitality of the dentine and its resistance to disease, are still in dispute, one school of investigators claiming that the vitality of a tooth resides entirely in the minute threads of living matter that radiate from the pulp, and that therefore caries is practically a chemical process; while another asserts that pus has been found within the dentine, thus showing that caries involves all the stages of inflammation.

One of the most prominent characteristics of organized beings and tissues is their capacity of maintaining their integrity against the invasion of disease. And though, as already stated, the teeth have a limited amount of vitality, they are more than merely organic chemical compounds, and have some capacity for resisting disintegration.

Of all parts of the system, the teeth are most exposed to destructive agents and have the least power of recuperation; though more readily replaced by artificial substitutes than other parts or organs, their intimate

relation to the vital function of nutrition makes their preservation of the greatest importance.

By reason of defects inherited or acquired, local or constitutional, the teeth of different individuals, and of the same individuals at different times, vary much in their liability to decay and in their recuperative power.

The health-status of the teeth depends on—

1. Inherent systemic and local tendencies;
2. On their proper and vigorous use;
3. On the chemical nature of the oral fluids;
4. "On their shape, relation to each other, and their self-cleansing features."

The readiness with which teeth yield to destructive forces depends on the number and extent of the inherent defects and the strength of the disintegrating agents. A perfect tooth can maintain its integrity under almost any abnormal condition, while an imperfect one can scarcely be preserved under the most favorable surroundings.

Secondary Dentine.—Dental lesions act as irritants and excite resistance. Wedl says that a deposition of secondary dentine can be induced only by an irritation in the contiguous portion of the pulp. "Irritation is the stimulus which causes the vital force of the part to make the reparative deposition." Stimulation is the requirement, but over-stimulation precipitates inflammation.

As, however, there is such a variation in the quality of the teeth and in the vitality of the pulp, irritation, especially in soft teeth, is always dangerous and should be avoided. As sensitiveness implies irritation of the fibrillæ, which are really branches of the pulp, a filling should protect what, as regards the organic elements, is really a wounded surface.

Remedies as well as filling materials, for soft teeth at least, should have therapeutic properties, and by their tonic or stimulating effect promote the recalcification of the dentine.

Saving Teeth.—Success in saving teeth depends—

1. On changing the conditions and removing the causes that produced decay;
2. On the judicious and skilful selection and application of stopping materials and other remedies.

If the causes that produced disease are not removed, teeth will decay after as well as before filling—first, in the defective parts; second, when all defective parts are removed they will redecay at some point in the parietes of the cavity, which is still, even after the most perfect operation, the weakest part. Though some seem to assume that the strongest part of a tooth after a perfect operation is around the filling, the converse of this is obvious enough, from the fact that a cavity cuts off the circulation and nutrition of the tooth.

Filling in General.

Of all operations in dentistry, the apparently simple one of filling a tooth has excited the most interest and thought and has given rise to the most discussion.

A. *The Tooth.*—1. The rationale of filling teeth is based on the fact that caries is not of internal or constitutional origin, but results from external and local causes; and though, in teeth of the better quality, the progress of caries may cease, the lost portion is never reproduced; hence, a filling must of necessity be a foreign substance in a vital organ.

2. The vitality of a tooth is preserved by maintaining its normal temperature, thereby preventing thermal changes and galvanic shocks, and by avoiding all other causes of irritation.

3. The two most important points requiring attention in filling are the nearness of the pulp and the condition of the dentine, to the end that the one may not be exposed to contact, pressure, or irritation, and the other may be so protected as to favor recalcification.

4. Since caries is dependent upon the presence of fluids for its development, a filling must exclude moisture; and, as the pulp is endangered and redecay often induced by irritants and by marked variations of temperature, a filling should neither irritate nor permit thermal changes.

5. A rational and judicious selection and combination of filling materials presupposes a careful diagnosis of the condition of the teeth and their surroundings.

6. Just where filling or restoring a part of a crown ceases to be good practice, and replacing the entire crown is demanded, must be determined by the strength of the remaining tissue as well as by the position of the tooth. It may be safely affirmed that if a tooth is so frail and defective that it cannot be saved without being discolored and disfigured, its root had better be utilized to support an artificial crown.

7. The possibilities of saving crowns by the present resources of operative dentistry may be difficult to define; but when the pulp is devitalized or should be destroyed, there can be no question that every effort should be made to preserve the normal condition and function of the peridental membrane, to the end that when filling is no longer available the root may be utilized for crowning, which is not only the most natural method for attaching artificial teeth, but, when properly performed, it is the most durable and satisfactory operation in modern dentistry.

B. *The Material.*—1. As already implied, the physical properties and chemical nature of a filling material should be such as not to disturb the normal temperature of a tooth nor endanger its vitality.

2. The three most essential qualities of a filling material are—first, softness, to admit of adaptation; second, hardness, to withstand the force of mastication; third, indestructibility, to resist the chemical action of the oral fluids.

3. A material should have no physical properties which, when the filling is inserted, will permit change of shape. A very slight expansion may be regarded as beneficial, but contraction and a change of form are always detrimental.

4. It being impossible to draw the line between nutritive and destructive irritation, all disturbance from this cause should be guarded against; and whether thermal changes affect the dimensions of a filling or not, the teachings of experience are that these changes should be avoided.

5. The teeth being an important element of personal beauty, a filling

material must not disfigure their appearance nor produce noticeable discoloration.

6. All materials should admit of comparatively easy and rapid insertion, so that the labor demanded and the pain to be endured in the operation of filling may be well within the respective capacities of operator and patient.

FILLING MATERIALS.—The filling materials which experience has shown to meet more or less perfectly the requirements are gold, tin, amalgam, the zinc plastics, and gutta-percha.

Fillings are merely stoppings or remedial agents, or both. Gold is the typical stopping. The zinc plastics are of all substances the most remedial or therapeutic in their action. Of the metals, copper is the only one that has tonic or stimulating properties. It is stated by Prof. Garretson that owing to its tonic action the deposit of secondary dentine is sometimes so great that the pulp-canal is contracted to a thread-like tube.

As regards saving the teeth and resisting disintegration, these materials have certain characteristics which indicate the extent of their usefulness; but nearly all of them have such pronounced deficiencies that their value is often much enhanced by their judicious combination.

These materials, taken in the order named above, preserve tooth-structure in one or more of four ways: 1, all by a more or less perfect exclusion of the oral fluids; 2, by a deposition of metallic oxides and salts, which cover the parietes of the cavity and permeate the dentine; 3, by therapeutic or medicinal effects on the dentine; 4, by their being non-conducting and non-irritating.

Assuming that they have sufficient anchorage, fillings fail in one or more of three ways: they are undermined by redecay, or worn away by attrition, or disintegrated by chemical action.

Although dentine in teeth above medium structure hardens somewhat under gold, this metal prevents redecay chiefly by excluding moisture. Tin preserves partly by close adaptation and partly by its oxide, which is deposited on the surface of the cavity. Amalgam, which, owing to change of shape, cannot generally be kept moisture-tight, depends for its tooth-conserving properties on a deposit of silver sulphide, which, like the oxide of tin, is insoluble. The zinc plastics by their tonic and stimulating effects not only prevent recurrence of decay, but promote recalcification of the softened dentine. This applies especially to oxychloride of zinc, which is at once the most preservative and perishable of all materials for filling teeth. Gutta-percha, though making a leaky filling, conserves tooth-bone by being non-conducting and non-irritating.

Gold, having the largest number of required attributes, has always been, and still is, the most useful material for filling teeth. Its limited softness make its use difficult in immature or imperfect teeth, while its color produces an unpleasing contrast with white or bluish-white teeth; but its conductivity of caloric is its most pronounced defect—a quality which always endangers, and sometimes destroys, the vitality of imperfectly calcified teeth. Its successful use, besides always requiring skill, demands a judicious selection of the various forms of soft and cohesive

foil, as well as a proper selection of other materials to be used with it as non-conductors or for filling the greater part of all large and deep cavities.

Historical Summary.—The operation of filling teeth has been practised for about a century. The first filling materials were foils of lead and gold. Adapting metallic foils to tooth-bone, especially with primitive methods and instruments, did not prove an easy or always successful operation; hence the early attempts to obtain a plastic material. The first plastics were simply ethereal or alcoholic solutions of some one or more of the gums, as mastic, sandarac, etc. These substances were necessarily of a very temporary nature. Next appeared the terra-metallic cements, composed of a mixture of sulphate of lime and oxide of iron. The addition of morphia to this made the celebrated anodyne cement. This mixture did not prove any more permanent than its predecessors. But materials of a more durable nature, in the shape of fusible metals, soon appeared. First came (about 1820) D'Arcet's mineral cement, which was simply "Newton's alloy of eight parts bismuth, five parts lead, and three parts tin, with, occasionally, the addition of one-tenth part mercury to hasten the fusing."

This alloy was, after some years (1860), succeeded by Wood's metal, which also soon fell into disuse. D'Arcet's metal was melted and poured into the cavity, while Wood's metal was placed in the cavity cold and melted with a hot instrument.

"About the year 1826, M. Taveau of Paris advocated the use of what he called 'silver paste' for permanent fillings. Under this, as it were, shining title was ushered into the world what was destined to be for years the Hydra of dentistry." This amalgam consisted of pure silver and mercury. But coin silver, being more easily obtained, soon replaced the purified metal. The coin was cut down with a file and mixed with mercury, the excess being removed by compression with pliers, the material being then ready for the cavity.

In 1848, Dr. Evans of Paris introduced an amalgam alloy consisting of tin and cadmium, which, owing to shrinkage and discoloration, was soon laid aside.

Amalgam was introduced into this country by two French adventurers named Crawcour, who opened an office in New York in 1833. The great pretensions of these ignorant and unskilful men, their charlatan methods, their pecuniary success, and the fact that their "royal *mineral*" contained mercury, called out the most decided protests and bitter opposition from the leading men of the profession. The attack was prompt and vigorous, and the repeated failures from operations which ignored putrescent pulps and other diseased conditions added the victims of this fraudulent dentistry to the army of the opponents. Defeat quickly followed, and these impostors were forced to fly.

Though the Crawcours were driven away, the "amalgam question" was not settled. For many operations and not a few operators this material had properties and advantages which could not be lightly set aside, and even prominent dentists endorsed and used it in their practice.

Individual opposition was in due time followed by the official action of the American Society of Dental Surgeons. In 1841 this society first

announced that any material containing mercury was injurious; it next declared (1843) the use of amalgam to be malpractice; and then (1845) it went to the extent of asserting that the *refusal* to sign a pledge not to use this material was equivalent to malpractice.

As might have been foreseen, the first measure, based on the injurious effects of mercury—a disputed point—did not accomplish its object, while the second measure, attempting as it did to control men's opinions if not their consciences, could not be enforced even among those who condemned the use of mercurial preparations. In point of fact, these measures were more effective in breaking up the society than in suppressing amalgam. The society retreated from its position by repealing the "protest-and-pledge" mandate, though strangely claiming at the same time that the resolutions had accomplished their object.

It has often been said that the antagonism to amalgam sprang wholly from prejudice; but the attitude of its opponents is easily accounted for when the nature and origin of the material is recalled in connection with the character of the men who introduced it to the profession. Again, it has been asserted that the opponents to this material were ignorant of its components and properties. The facts in the case are, that those who opposed amalgam did so because they knew it was composed of base metals, and because mercury was an essential ingredient, as well as because it discolored the teeth and disfigured the mouth. Not a little has been claimed for the tests and experiments to which the advocates of amalgam subjected this material; yet we look in vain for any evidence that these alleged investigations proved anything or established anything reliable.

For about twenty-five years amalgam was made from coin silver and mercury. Excepting Dr. Evans's objectionable formula, none was given to the profession till 1855, when Dr. Elisha Townsend of Philadelphia published his formula for an improved amalgam alloy.

The most conspicuous fact in connection with the use of the silver-coin amalgam was that fillings made of it turned almost black and imparted their color to the teeth. Dr. Townsend's alleged improvement consisted in refining out the copper, and making the alloy to consist of five parts of tin and four of silver, and, after mixing, washing the mixture with alcohol. This formula was gradually modified until it consisted of six parts of tin and four of silver; and it was then improved by a small addition of gold, and is used to some extent at the present day. As at first made, the color alone was really improved, while the tooth-conserving properties of the alloy were decidedly damaged. But so little was actually known, in spite of alleged investigations, of the properties of this material at this time that, though it was now used more extensively than ever by some of the best men of the profession, about three years elapsed before it was evident that amalgam largely "tinned" and washed had parted with most of its tooth-saving qualities. This view is based not so much on the writer's experience as on the conclusions of Dr. J. Foster Flagg, who has devoted about twenty-five years to practical work in plastics. He changed and improved Townsend's formula until it consisted of nine parts of tin and thirteen parts of silver.

So disappointing had been this improved amalgam that a number of prominent dentists obtained from Dr. Townsend a "recantation," in which, for specified reasons, he renounced the use of amalgam entirely. Dr. Flagg, who had taken up the subject of plastics, in particular amalgam, in 1855, and had been using Townsend's improved, regarded this "recantation" with "peculiarly painful professional feelings;" which, with much more that could be quoted, would seem to imply that amalgam has depended as much on endorsement and recognition as on its known qualities or genuine merits.

In consequence of the failure of Townsend's amalgam to satisfy the expectations which had been raised, the use of this material was checked for a time, at least among the better class of dentists. From this time (about 1860) until 1874 not much of value was done either to help or hinder the progress of the plastics.

In this year Drs. Hitchcock, Cutler, and Bogue published the result of their investigations on amalgam alloys, which gave a new impetus to the amalgam question. About the same time Dr. S. B. Palmer, a conservative practitioner and a reliable investigator, published the electro-chemical theory, which has for its basis the incompatibility of filling material with tooth-bone. This theory at first excited but little attention, but subsequently became a theme of animated discussion.

During these years (1860 to 1875) the dental profession had greatly increased in numbers, partly in consequence of the introduction of plastic bases and plastic filling materials, which almost any one was supposed to be able to manipulate successfully, while during the same period inventions and improvements had multiplied very rapidly; and yet the resources of dentistry did not seem to keep pace with the demands of the age. Though researches, by showing the true nature of caries, had confirmed the teachings of experience as to its remedy, the most careful and skilful efforts were not always rewarded with success; hence the cause of redecay around fillings soon became a leading question. The presence of a foreign body in the dental tissues, metallic contact, thermal shocks, and the consequent irritation,—neither one nor all of these had been generally accepted as sufficient to account for the ever-recurring secondary decay. It seems that in defiance of the boasted progress of dentistry, and even when improvements in appliances and instruments were multiplying the most rapidly, one fact was too conspicuous: operative dentistry did not seem to be meeting the reasonable expectations of its patrons nor always proving a credit to its practitioners.

It is more than probable that in many cases too much had been attempted—that the possibilities of saving soft and frail teeth and the limitations of materials were not sharply defined or clearly recognized. In view of the great diversity in tooth-structure and surroundings, and the varying degrees of skill in operators and in the same operator at different times, the subject of the causes of this partial failure is somewhat complicated. In short, the causes of failure constitute a problem containing too many unknown quantities to admit of a solution which can make any pretentions to absolute exactness.

Again, there is no doubt that too much had been expected of cohesive gold—a material which had been in general use about fifteen years

when failures became a prominent theme of discussion—and there was no little disappointment. It is a fact few will dispute that to the indiscriminate and unskilful use of gold many failures were undoubtedly due; and it will doubtless be admitted that a careless and even slovenly use of the plastics will save teeth as long at least as the unwise application of gold, even when manipulated with some degree of skill.

The real or apparent increase of failures, together with the want of success in using gold, resulted in the so-called "New Departure," which may not inaptly be termed "The Plastic Revival." This movement had as its authors advocates of all grades, from the careful investigator to the partisan extremist in exclusively plastic dentistry—the one practically repudiating the other because of the latter's going "to an extreme which few will choose to follow." This movement is entitled to some notice in the present survey of the history of plastics, for the reasons that it was not without its influence in modifying practice, and because it adopted, and was discussed in connection with, the electro-chemical theory. At the same time, its extreme and extravagant teachings and tendencies require no comment, since these contained within themselves their own effectual remedy.

As to the "electro-chemical" theory, it may be said in general that though it accounts for much that occurs in the teeth in connection with the contact of different metals, it is difficult, not to say impossible, to demonstrate its truth or falsity in the oral cavity. The experiments made out of the mouth for which so much has been claimed are not generally accepted as proving anything conclusively; and where several disintegrating agents are at work it is no light task to assign to each its actual share in the work of destruction. It has been claimed by some that no theory is needed, that nothing need be assumed, since the presence of a foreign body, the irritation of thermal changes, the abnormal condition of the parietes of the cavity, account for all.

The necessity for a moisture-proof joint as a barrier against redecay had always been recognized; now there was a new theory—viz. contact tends to arrest or increase electrical and chemical action. Still, something, as usual with theories, had to be assumed. The theory may thus be summed up: Thermal changes induce electrical currents, attended by chemical action. Everything contains latent electricity, which may be developed into a current; any metals and tooth-bone and moisture make a battery; if the metal is acted on, the tooth is saved; if the reverse, it is destroyed. Dr. Chase claims that galvanism or electricity greatly intensifies chemical action, which is the destroying force, and that the best conductor makes the strongest battery. In attempting to establish this theory, as in pathological investigations generally, vitality proves to be a formidable barrier. There were admitted to be also some "discouraging mysteries" presented by the complexities of electrical phenomena, so that the exact relation of electricity to *composition* and *decomposition* is not determined.

Whether irritation or electricity, directly or indirectly, be the cause of redecay, the practical teachings are these: In all teeth exclude the oral fluids; in soft teeth, in addition, interpose non-conductors between the filling material and the dentine.

Though the plastics had been in general use from twenty to forty years, and had been frequently found wanting, it was now earnestly advised that practice should be so modified as to accord with a dominant chemical law which could not, from the nature of things, be clearly established. The need of more effectual means of saving teeth was conceded, but it must be evident that there was, and is, more demand for better work among the many than for extending the use of the plastics among the few; for, as a matter of fact, the plastics have always been much more used than gold. It is conceded that American dentistry, both as regards theory and practice, is the most advanced and progressive. This superiority is most evident in the skilful use of instruments and appliances and the generally successful use of gold in filling teeth. One of the most striking characteristics of European dentistry is the extensive use of the plastics, this also being the most distinctive feature of the least progressive of American dentists.

What principally strikes the reader of the "New-Departure" literature is the confident and positive tone of the partisans of the movement, most of them complacently predicting a revolution in dental practice. The true scientist is supposed to assume nothing, and to assert anything not freed from doubt with great caution; but in most of this literature assumption is based on assumption and assertion piled on assertion, as if the sword of conceit could cut through the most knotty problems. A careful contrast of the guarded and qualified statements of Darwin and Tyndall with the positive and confident manner of many plastic partisans would be a benefit to dental science.

Though called new, it is difficult to define precisely in what the newness consisted. There were no new materials, all having been in use for some time and several for forty years. The abandonment of gold was not advised, except by the chief advocate of the movement. Even the theory of the "New Departure" was not new. Dr. W. H. Trueman points out the fact that Dr. Fonerdon in 1833, and Dr. Josephus Brockway in 1839, broached the same theory; and as early as 1820 attention was called to the injurious effects of the galvanic current on the teeth. Dentists were then advised never to combine tin and amalgam, and it was claimed that all trouble ceased when gold was substituted. In point of fact, from that day to this the better class of operators have to a great extent replaced the base metals with gold. And it may be added that the evidence and arguments used then were fully as strong and as convincing as those used now.

Not a little of the opposition and ridicule the "New Departure" encountered can be traced to the methods and manner of some of its advocates. It may be safely asserted that facts and truths which all progressive practitioners are seeking require no such impassioned appeals or such a liberal use of italics and capitals to secure their recognition. In respect to the immediate influence and permanent value of this movement, it may be observed that many who imagined that they had found a specific for failures and disappointments soon came to the conclusion that the operator must be guided (to quote Dr. Bogue's compact summary) "by a judgment based, not on the questionable work of one, but on the carefully-collated knowledge of many."

Amalgam.

Amalgam has been utilized for filling cavities in carious teeth for about sixty years. Some of its enthusiastic advocates have regarded it as a "special providence," while not a few of its bitter opponents have styled it "an imp of darkness." While some have claimed that it conferred "the greatest good on the greatest number," others affirm that it is "used only by incapables and endorsed only by imbeciles." In short, it has been charged and credited with defects and qualities which would indicate that it is at once the worst and best material in existence.

Gold and amalgam—a metallic foil and a metallic paste—have always been regarded as rival materials; and though gold has the largest number of desirable qualities, its marked deficiencies have scarcely checked its too extended use, while the strong points of amalgam, decided as they are, have never overcome its objectionable features. In other words, it has been more difficult to keep gold within proper limits than to give amalgam its true status. It has been claimed that amalgam, being used almost always in difficult and doubtful cases, has not had a fair trial; but it is evident that this claim is based on the assumption that this material is as difficult to use as gold. It is remarkable that if amalgam has all the good qualities claimed for it by its most pronounced advocates, it should have had such a long, hard struggle for recognition. On the other hand, the fact remains that in spite of its ignoble nature, and in defiance of some prejudice and much opposition, amalgam has steadily won its way, until it is endorsed and used, to a limited extent at least, by many of the best operators.

Though amalgam cannot be regarded as a specific for the most frequent of dental lesions, it is, with all its defects, the most durable plastic that the inventive skill of the profession has produced. No condition or position of teeth and cavities precludes its use, as it sets almost undisturbed by the presence of moisture; and on the score of comfort and economy to the patient nothing more could be desired. Its limitations are, however, often ignored.

It may be said, in general, that amalgam, with all its real and alleged defects, including mercury as an essential ingredient, is to operative dentistry what vulcanite is to prosthetic dentistry. Both dispense with the highest skill and lower and cheapen dentistry, but at the same time bring it within the reach of those who could not otherwise avail themselves of its service. It was opposed from the first, not because it failed to save teeth, but because when it preserved them best it generally discolored and disfigured them most; and it still often contains metals that have not been proven to be harmless. Nor is it to be wondered at that a material which saved teeth more or less perfectly by destroying their beauty more or less completely should have encountered the most decided opposition.

Discoloration.—Admitting that the metallic salts by permeating the dentine tend to heal and harden the softened and sensitive surface, discoloration must still be viewed as damaging, if not destroying, the appearance of the teeth, which by common consent are considered an

important element of personal beauty. Notwithstanding the claim that "considerations of beauty have obtained notable prominence in plastic work," the mainstay of the "plastic-filler" can show but little semblance to that quality, except at the expense of utility. In order to save, amalgam must discolor; and this darkness will deepen in proportion as teeth are soft and need saving. In other words, it is a singular fact that from an æsthetic point of view the chief demerit of amalgam is *practically* its strongest point: it discolors and darkens in proportion as it preserves. The action of sulphur on silver and oxygen on tin and other metals accounts for this discoloration. Yet there is a limit to the beneficial effects of metallic salts and oxides permeating the dentine; for an excess of "sulphuretting" or oxidizing destroys a lamina of the metal, making a crevice, which, by retaining the oral fluids and the semifluid portions of the food, becomes the seat of redecay. On the other hand, these metallic salts when deposited in the dentine become insoluble, and, though a filling may leak slightly, the tooth will generally be preserved.

Discoloration implies a soluble material, a solvent, and porosity in the tooth; hence it is promoted by moist teeth and cavities, and is also increased by a careless and improper use of the material in a dry cavity. The greater the organic portion of the tooth, and the greater the amount of moisture, the deeper will be the discoloration. Any mode of making or mixing amalgam that will prevent change of form in the filling will limit or reduce darkening of the tooth-bone.

The Spheroidal Tendency of Amalgam.—One of the most striking characteristics as well as prominent defects of amalgam is its change of form while hardening in the cavity. It was formerly held that amalgam expands—a fallacy that finds its supposed basis in the fact of the bulging of the face or surface of a filling. It is obvious that here the spheroiding would be most positive, because of its not being limited or controlled by the cavity-walls. Again, the crevicing around a filling seemed to be positive evidence of contraction, but closer observation and experiment revealed the fact that this crevicing is most marked in the angles, along straight sides of fillings, and at the ends of those that are relatively long and narrow. In short, an amalgam filling does not expand, or there would be no crevicing around its edges; neither does it contract, else there could be no bulging of its surface. An amalgam filling neither increases nor decreases in size, but tends to change its shape to that of a ball. This theory accounts for the largest number of facts, and the phenomenon is known as the "spheroidal tendency." It might be safely inferred that the same law which determines the form and arrangement of globules of mercury (as well as that of other fluids and semifluids) would have some influence in determining the shape of a mass of amalgam. It is an indisputable fact that amalgam fillings do change in form; and this change is generally in proportion to the amount of mercury and the softness of, and the slowness of setting in, the metals that compose the alloy. This is a case in which the cause seems scarcely adequate, but the effects cannot be accounted for so well in any other way. An amalgam filling can seldom or never be a true sphere,

and is generally an irregular mass. Upon this point the researches of Dr. J. S Dodge are notable, and are here reproduced:[1]

"The tendency to a spherical form, as in a drop of mercury, is the result of the mutual attraction of all the molecules, which is most nearly satisfied when they are arranged symmetrically around a centre. When the particles are perfectly free to move they will abandon any other arrangement and move—each, of course, as directly as possible—into this. If obstacles interfere, the nearest possible approach will be made to the sphere, with more or less failure to reach it; the governing law being, that at every point the original outline will so change as to approach the outline of a sphere having the same cubical contents.

"Thus, in Fig. 142, if A, B, C, D is a section through the middle of a cube, and this is to change into a sphere of which the circle is a section, G being the centre of the mass, not only must the diagonal, B, D, shorten so as to draw the points B and D inward, but of equal necessity the transverse diameter, E, F, must lengthen so as to thrust the points E and F outward. And all intermediate points will move in the one direction or the other, except those which are at the exact distance from the centre required for

FIG. 142.

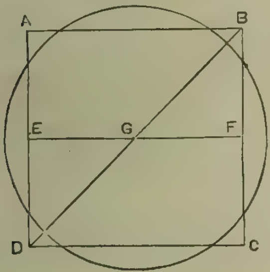
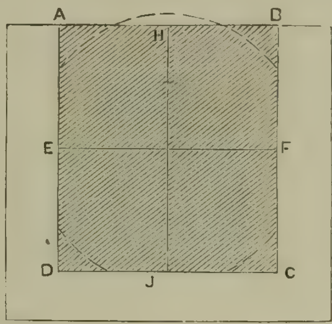


FIG. 143.



the sphere. Let it be carefully observed that lengthening of the short diameters is just as much a necessary part of the change as shortening of long ones. From this may be stated the following law, which governs the whole subject: 'When an irregular mass tends to assume the spherical form, every point of the surface which is more distant from the geometrical centre of the mass than the radius of a sphere of equal bulk will move toward the centre, and every point less distant will move from the centre.' Or, in simpler terms, all long diameters will shorten, and all short ones will lengthen. We may next advance the discussion a step by supposing the mass to be surrounded by an unyielding matrix, except on one side, as in Fig. 143.

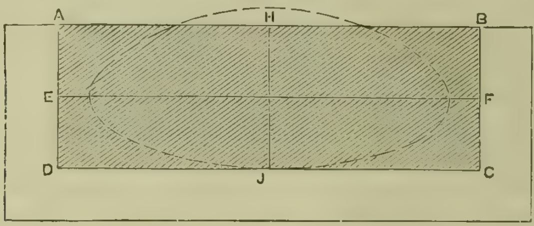
"Here the matrix makes it impossible for the transverse diameter, E, F, to lengthen. The only effect in this direction will be the closest possible adaptation to the walls at E and F. But the vertical diameter, H, J, can elongate by the pushing outward of the mass at the free surface, H, and this is increased by the contraction of the angles, A, B, C and D, and also by the push against the unyielding wall at J, so that the bulging surface will be the result of both the contraction of long diameters and the expansion of short ones; in a word, the overflow of the readjusted mass. Ob-

[1] From *Dental Cosmos,* July, 1884.

serve, too, that the mass will be solidly impacted in its matrix, and the sulcus at A and B will be shallowed.

"Now let us change the proportions of the mass, as in Fig. 144.

FIG. 144.



"Here the mass is broad and shallow, and consequently the spheroidal tendency will shorten E, F, and lengthen H, J, with retraction of all the angles. The consequence will be a total departure from the walls; the sulcus at A and B will extend to the bottom of the matrix, and if this is reversed the mass will roll out. Another change of figure will illustrate a different result (Fig. 145).

"Here the form is a little more complex, but the same principles are easily applied. The diameter, E, F, will tend to lengthen, and will simply tighten the fit against the walls; H, J will for the same reason tend to shorten, and will draw the projecting edge, A and B, tightly against the borders of the matrix, while the angles, D and C, cannot withdraw from their position because a compensating protrusion of the mass is nowhere possible. Thus it will be seen that precisely the same tendency which in Fig. 144 sets the mass free from its matrix and allows it to drop out, will in Fig. 145 tighten its adaptation at every point.

"These are theoretical deductions, but I think every dentist has seen their application to practice while I have been speaking. Let me remind

FIG. 145.

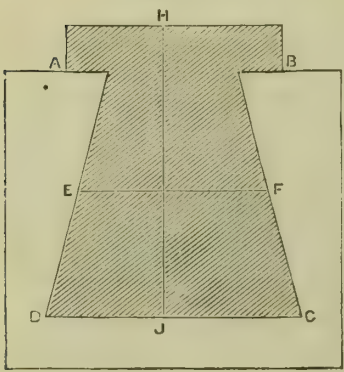


FIG. 146.

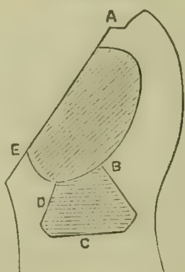
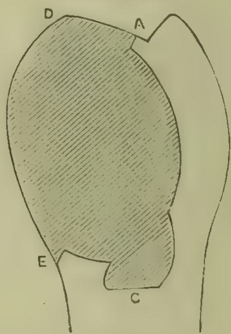


FIG. 147.



you of facts which correspond to these deductions. The bulging surface and the marginal groove are familiar enough, but perhaps it needs a word to remind us that when this groove is cut out for repair it is sometimes found shallow, with an excellent adaptation of the amalgam to the walls at a slight depth, while in other cases there is no bottom to the groove until the bottom of the cavity is reached. I think observation will show that in

the former case the long diameter of the mass is perpendicular to its surface, so that the filling has swollen laterally, while the other fillings are wider than they are deep, and so have contracted from side to side. These correspond to Figs. 143 and 144. It must also have been noticed that large fillings, which go deeply into the tooth and are freely built out to contour, afford the most perfect edges. Indeed, I have seen many, even in past years when less perfect amalgam was used, that were remarkable for their exactness, and I have seen some in which thin edges of enamel had been crushed in. This is explained by Fig. 145. The contoured part of the filling is drawn in against the edges. Again, in proximal fillings of moderate size, which admit of no great depth, it is sometimes found that the adaptation is very good, while in other cases such fillings unaccountably drop out. I think it will be found that those which fail are of an oblong shape, and have been fastened by slight undercuts at the ends of the long diameter, so that in shortening and thickening they have lost their hold, while similar fillings will hold perfectly if fastened by undercuts at the sides; that is to say, at the extremities of the short diameter, which will tend to lengthen.

"I do not propose to give any detailed rules for applying what has been stated above, but only some suggestions. The governing principle is, that the original form of the mass of amalgam determines the changes which will take place in its parts; and by remembering that long diameters will shorten and short ones lengthen the dentist can frequently control the result by varying the form of the cavity and filling. Let me illustrate this by a single case, treated in two ways, which will make the matter so plain that it may fitly terminate this paper:

"Suppose Fig. 146 to show a longitudinal section of a molar, filled into the pulp-chamber from a proximal cavity, the walls of which have been freely bevelled at A, E. A, B, D, E is amalgam, and B, C, D is zinc phosphate in the pulp-chamber. Now, if the amalgam used has much spheroidal tendency it will shorten in the direction A, E, and draw out of the undercut which holds it, while it will lengthen in the opposite direction and bulge out of the cavity. The fit will be lost and decay will soon recur. But let us fill it differently, as in Fig. 147.

"The pulp-chamber is now made part of the cavity, and the amalgam carried into it, while the mass is freely contoured, A, D, E. The result now is that A, E is a short diameter, and will tend to increase, and so tighten the fit, while D, C, being a long diameter, will try to shorten, and so will keep the borders, A and E, as tight as they were at first."

It remains to add that Dr. Dodge disclaims "an undoubting belief in this theory, but suspects that it will give place to something less remarkable."

It has been demonstrated that the lower the melting-point of the metals which form the alloy, the greater the spheroidal tendency, and, on the other hand, the higher the melting-point and the lower the degree of ductility, even when the metals are mixed with a little larger quantity of mercury, the less the liability of the amalgam to change form in the cavity. The first of these points is well illustrated when tin is in excess, and the latter when silver is in excess. The less mercury used or the drier the mass within certain limits, the less the spheroiding; and if an excess of mercury be used, especially when tin predominates, evaporation will be added to balling up, and the most marked evidence of spheroiding as well as contraction will appear.

Alloys in which silver predominates are but slightly subject to change of form.

The Ideal Filling.—It has been well said that the ideal filling material is a plastic—a material which admits of prompt insertion, easy adaptation, rapid and thorough hardening, becomes impervious to the oral fluids, and by its adhesion to the parietes of the cavity makes a moisture-proof joint, besides being non-conducting and non-irritating and having a more or less natural color and vital appearance. But all the plastic materials which have thus far been utilized, except amalgam, are deficient in the essential attribute of indestructibility. Amalgam is therefore, with all its defects, the most permanent and generally useful of the plastics for the posterior teeth. Yet even here phosphate of zinc and gutta-percha can be substituted for it, these substances being renewed when partially disintegrated and worn away by attrition. The fact that gold fillings "that would last a lifetime do not save teeth a year" shows that either this metal requires too high a degree of skill in its manipulation or that some plastic will better meet the requirements in soft and frail teeth.

Inferior operators fail, not, as is often claimed by plastic advocates, so much because of their limited use of amalgam, as by its careless and indiscriminate use and by their want of skill in manipulating gold. While one may consider "its glorious attribute of easy working" as a strong point in favor of amalgam, another can just as truly assert that its fatal facility of easy insertion has hindered rather than helped the substantial progress of dentistry.

METALS USED IN AMALGAM ALLOYS.—Before making an alloy for dental amalgams it is necessary to know both the attributes of the metals used and their properties when combined.

Two or more metals united form an alloy.

The majority of metallurgists hold the view that alloys are true chemical compounds, and give as evidence the facts that heat and incandescence accompany their formation; others claim that alloys are merely mechanical mixtures, since the qualities of the individual metals not only appear, but vary with the amount introduced. According to Matthiesson, alloys partake of the nature of compounds and mixtures, chiefly the former.

Silver.—The greater number of amalgam alloys consist almost entirely of silver and tin. The former metal must predominate or there must be proper amounts of copper and zinc or gold and platinum. "Silver is the first, the most important, the essential metal for a good amalgam alloy for filling teeth" (Flagg). The original amalgam was properly named "silver paste;" a modern amalgam can be as truly called "metallic paste." This essential or basic metal is the largest component of all amalgams which discolor and are non-contractile—both of which properties are decidedly preservative of tooth-structure. Lawrence's is an old and well-tested alloy of this kind, and few if any amalgams preserve teeth better or discolor them more. It also contains about 5 per cent. of copper, which establishes a "tolerance" in the tissues and favors recalcification. Though to avoid discoloration many modern amalgam alloys have tin as their chief constituent, it is still possible, as

is shown by Flagg's "facing" alloy, to have 45 to 50 per cent. of silver, and yet usually have good maintenance of color.

Tin.—Though third in the order of time to be used in alloys for dental amalgams, Dr. Flagg places tin "second in importance, upon the grounds of quantity and usefulness."

An alloy containing more than 45 per cent. of tin is soft, sets slowly, is deficient in edge-strength, and has a decided spheroidal tendency; but it makes mixing easy, prevents discoloration in a marked degree, and reduces conduction. Gold and copper in such an alloy increase hardness, hasten setting, and control shrinkage.

Townsend's is the typical tin amalgam alloy. It does not discolor or disfigure the teeth to any extent, but it fails to preserve them. The formula was improved by the addition of a small amount of gold, and it is used by some at the present time, probably being kept in the market by its low price.

Copper.—This metal was at first and for some time regarded as a deleterious, if not actually poisonous, ingredient in amalgam alloys. The real or fancied bad effects of copper developed a tendency to discard this metal, increase the quantity of tin, and reduce that of silver. This, however, does not apply to English dentists, who continue to use copper even in increased quantities, with an improved record in the saving of teeth. Lawrence's and the "Standard" alloy may be mentioned as showing the good effects of the presence of copper. Of all the metals, this has the most decidedly tonic or therapeutic properties. Dr. Flagg says very white alloys result from admixture of copper and gold with tin and the required proportion of silver.

Copper diminishes shrinkage, hastens setting, is compatible with tooth-bone, and favors tolerance of metallic filling near the pulp, and promotes the immediate if not always subsequent whiteness of the filling. "For these reasons," says Dr. Flagg, "I regard it as a most valuable component of dental amalgams."

Gold.—This metal Dr. Flagg regards as the most undetermined component of amalgam alloys; but though, as he says, opinions vary, enough are in unison to show that it is worthy of a place in our consideration. Opinions differ as to its control of setting, color, and density; and, though some assert that like tin it favors softness, the experiments of Mr. C. S. Tomes clearly prove that it does prevent shrinkage. Though gold does not tend to make a white amalgam, it resists corrosion and discoloration, and by its toughness improves edge-strength. Some of Dr. Bonwill's views and opinions may be thus summed up: Gold makes the mass smooth and more plastic, reduces oxidation, and hastens setting. It also dispenses with the necessity of compressing with pliers. The mercury he uses with his alloy contains 7 per cent. of gold—a mixture that ensures very prompt amalgamation. He packs with bibulous paper, which absorbs the mercury as it is forced to the surface. The tarnish on such fillings is very superficial.

Zinc.—In regard to this metal as a component of amalgam alloys some experimenters think that nothing is finally settled. Dr. Flagg says its possibilities may be something of vast importance. He further

says the effect of zinc is "peculiar," imparting certain properties that are evidently not sharply defined or easily discerned.

Other experimenters affirm that of all metals zinc has the most marked influence in maintaining a good color, and it is therefore an important constituent in silver and copper amalgam alloys. It also controls shrinkage, and it therefore counteracts the bad effects of silver and tin—discoloration and softness.

Platinum.—Its name without its presence has given more than one alloy standing and even prominence. On the merits of this metal views differ. Dr. Flagg thinks it more than probable that it may be positively detrimental—a view that conflicts with what many regard as established facts. He further adds: "I believe that one part of zinc is worth a dozen times more than a dozen parts or any other number of parts of platinum."

Dr. H. S. Chase says that the best amalgams contain gold and platinum. Dr. C. J. Essig states that its value appears when used with silver, tin, and gold. It causes quick setting and gives great hardness. None of these metals can be left out without detriment. Unless finely divided, as by precipitation, platinum has little affinity for mercury.

Experiments with platinum have given few facts and have caused much conflict of opinion. It is said to impart strength and density, and, like gold, to resist corrosion and discoloration.

Besides these six, other metals have been experimented with, but all of them have been proved to be worthless or positively detrimental in amalgam alloys.

From the foregoing it will be seen that—

1. Amalgam alloys are composed almost entirely of silver and tin, these metals constituting from 85 to 95 per cent. in the different formulas.

2. Silver must either be the chief constituent, or, when tin predominates, there must be the proper amounts of gold and platinum or copper and zinc.

3. In general, the less a two-metal alloy—silver and tin—changes shape the more it changes color, and *vice versâ;* hence an alloy in which silver predominates should contain gold and zinc.

4. Silver, copper, platinum, and zinc are the metals that ensure hardness and permanence of form. Tin and gold render amalgamation prompt and easy.

5. As amalgam preserves chiefly by a deposition of metallic salts in the dentine, any combination of metals that entirely prevents discoloration, at least in soft, moist teeth, will be detrimental to the tooth-conserving properties of this material.

From the above summary it is evident that at least two kinds of alloys are needed to meet the varying and conflicting requirements and conditions of teeth and cavities, the first being chiefly designed for saving the teeth, the other to prevent an unsightly appearance.

The Making of Amalgam Alloys.—The formulas for these are numerous, and the last is uniformly the "best." Not only the manufacturers, but practitioners, often make claims of superiority that would seem to indicate the possession of much exact knowledge and the happy

meeting of all requirements and conditions. It must be said, to the discredit of many dentists, that lack of information in the practitioner respecting the components and properties of amalgam too often makes it necessary to depend on the manufacturer; which is equivalent to the apothecary prescribing for the physician. If, in addition to this, the choice of the filling material be left to the caprice or fancy of the patient, the *doctorate* finds a somewhat shadowy foothold. A few facts well assimilated would soon reveal the real nature of wonderful alloys so made by new processes as neither to shrink nor discolor, and to be markedly superior to all predecessors.

The following are the formulas for some of the best-known amalgam alloys:

Lawrence's Alloy.

Silver,	47
Tin,	47
Copper,	5
Gold,	1

Flagg's "Facing."

Silver,	50
Tin,	42
Gold,	5
Zinc,	3

Flagg's Submarine.

Silver,	50
Tin,	43
Copper,	7

Peirce's Alloy.

Silver,	12
Tin,	10
Gold,	1
Zinc,	1

Fletcher's Alloy.

Tin,	56
Silver,	40
Gold,	4

In making an alloy the order in which the metals are melted is a matter of some importance, though on this subject there is difference of opinion and practice. When a two-metal alloy is to be made, the silver is usually melted first, or the silver and the tin are melted separately and poured together. Borax must be freely used to prevent adhesion of the metal to the sides of the crucible and to prevent or remove oxidation. This can also be prevented by covering the metals with small pieces of charcoal. The following is Dr. E. T. Darby's method with a gold-and-platinum alloy: "The silver should be melted first, and when at a boiling heat the platinum should be added in very small particles, either rolled into thin ribbons or cut into minute pieces. Next, the gold should be added, and lastly the tin." The "New-Departure" method is thus described: "For the making of alloy the Hessian or sand crucible is used. In this is first fused a very liberal portion of borax, sufficient in amount to fill the crucible at least one-third full of the molten salt. This is intended for a flux. Any ordinary coke or coal fire is all that is required for the melt; but it is of course more systematically, and perhaps more readily, done at the usual dental or smelting forge-fire.

"Having perfectly fused the borax in it, *the tin is melted first*, requiring but a low temperature, and after it is melted the granulated silver

is added. It is really remarkable, when the high fusing-point of silver is considered, with what facility this metal is taken up by molten tin. These two metals are thoroughly stirred together with an iron rod or clay pipe-stem of small size and suitable length, and when completely incorporated the copper—small pieces of wire—is added. This, like the silver, notwithstanding its fusing-point of almost 2000°, is soon melted, and may be equally homogeneously stirrred together with the iron rod or pipe-stem.

"When perfectly melted and mixed the fused mass should be quickly poured into a broad, open, flat, shallow matrix made of iron or soapstone; this favors prompt cooling, and thus secures the greatest uniformity of distribution to the components."

The ingot is then cut into grains with a file or turned on a lathe into shavings. It has been said that a good alloy should not clog a fine file. After cutting it is advised to pass the filings through a fine sieve, to remove all foreign substances or coarse grains, and then remove the small particles of iron from the mass by the use of an ordinary magnet.

It is said that alloys that have been cut for two or three months, or even longer, fill the particulars of general excellence better than those that have been recently prepared. Why age or exposure, which can only oxidize the filings, should notably improve them, is not apparent; certainly it does not accord with conditions of easy and clean mixing. As the rationale of this "ageing" is not given, it must be accepted as the doubtful inference from observation rather than the outcome of exact knowledge.

Tests of Amalgam.—There are many tests to which amalgam may be subjected before being placed in the teeth, and all these have their merits; but the only tests of real value must be made in the mouth. Teeth which for any reason, to relieve crowding and correct irregularity, etc., must be extracted, should first be filled with great care. It is needless to say that a few teeth filled in this way will teach more of real value than many experiments made in any other manner. Next to these are such experiments as can be made in freshly-extracted teeth to determine the change of form in fillings and their capacity for excluding various fluids which have been colored for the purpose. Tests in dry teeth prove nothing, except that fluid-tight fillings cannot be made. Glass tubes show clearly all that glass can reveal respecting the amalgam packed into them; but the difference between tubes of glass and cavities in teeth fairly suggest the distance the investigator is from reliable conclusions. In a word, no tests but those in the teeth and in the mouth have any real value.

Preparation of Cavities.—That cavities should be prepared with the same care for amalgam as for gold is one of the plainest lessons of experience. The principles underlying the preparation of these two classes of cavities are not the same, and, in fact, differ as much as the nature of the two materials, which can be more easily contrasted than compared. The physical properties of the two materials, the different methods of insertion, determine and demonstrate this difference.

1. Not only the shape of the tooth, but mechanical requirements as

well as æsthetic considerations, demand that the walls of a cavity should generally form the segment of a circle.

2. A cavity for gold requires easy if not direct access, and demands smooth, strong walls, that the gold may be perfectly adapted without breakage or leakage.

3. A cavity for amalgam should be ball-shaped, that it may conform to the spheroidal tendency of this material. But few cavities can always have this shape. As a rule, crown cavities without fissures can have the globular form, but the surface of the filling must of course be concave. The small proximal and many buccal cavities can be shaped to harmonize with this requirement by making the surface of the filling decidedly convex, and after setting partially trimming it away.

4. Gold requires the removal of thin enamel-walls and a decided bevel of the border. For amalgam the enamel-walls should be parallel, the angles drilled out, straight sides made concave, and the cavity enlarged within. The enamel should not generally be bevelled, as this tissue and amalgam have about an equal degree of brittleness. An exception to this is found in those crown cavities that can be filled with a convex surface, which after setting is partially trimmed away. Dr. Dodge points out (Fig. 145) that the walls of such cavities can be bevelled with advantage.

5. While no dead or disorganized dentine should be allowed to remain in a cavity for either material, a little more decayed or soft dentine can be left in with amalgam than with gold. The undercut implied in "*the holding-power of a properly-prepared periphery*" generally removes all decayed and even softened dentine, except that on the floor of the cavity.

To sum up: Cavities are prepared with the same care for both materials, but there is this difference in the results: defects which would be of no consequence with amalgam would cause prompt failure with gold.

The "plastic-filler," by aiming "to make his cavity a concavity to the extent of his ability," strives to avoid his "bugbear" of *crevicing* and consequent leakage; for, try as he will to ignore much that is peculiar or special to gold-working, he is forced to recognize the necessity of a moisture-proof joint.

Preparing crown and proximal cavities with a view to resisting the forces to which they are exposed can be better contrasted than compared. The action of mastication tends to drive a crown filling into the cavity and to force a proximal filling out of it; hence *decided* anchorage in the former is of little consequence, while in the latter it is an essential requirement.

No matter what material is used, the treatment of the proximal surfaces of bicuspids and molars constitutes one of the most difficult problems of operative dentistry. The following extract, taken from a published article of the writer, is given because it summarizes all that relates to preserving these teeth, protecting the gums, and securing a free circulation of the oral fluids: "On these surfaces we have defective enamel, which is most exposed to the action of acids and least benefited by the wear of mastication. Because contact permits retention of food and stagnation of oral fluids, and favors decay, the proximal surfaces are separated; and because contact favors decay and the natural shape

of the tooth is best, the teeth are first separated and their original outlines restored by filling. *Contour is separation made permanent.*

"Both systems have in some respects been found wanting. Separation cuts away *surface*, which contour restores. Separation favors *change of position*, which contour prevents. Separation exposes the gum to pressure, inflammation, and detachment, while contour gives it entire protection. But contour favors stagnation of the oral fluids, a condition which greatly favors decay; separation permits their circulation, a condition which is antagonistic to decay. Contour derives one of its strongest points from separation, while one of the worst evils of separation—change of position—is prevented by contour. Separation removes defective enamel and often exposes the dentine, which may or may not be protected by filling; contour, after removing defective enamel and dentine, replaces these tissues by a metallic proximal surface."

It has often been asserted—and it is true—that in soft teeth leakage will occur in spite of all precautions and with any material. This leakage is internal, and the moisture is simply the vital fluid of the tooth; and so long as this is normal disintegration of tooth-tissue cannot occur. As soon as the oral secretions are admitted and mingled with the vital fluid the breaking down of the dentine promptly begins. An amalgam filling may leak, and yet the metallic salts which permeate the dentine may for a longer or shorter period prevent the recurrence of decay. Besides this, it is claimed that the *metallizing*, as it may be termed, of the dentine establishes a "compatibility" or "tolerance" which neutralizes the destructive irritation resulting from the contact of a foreign body with a vital organ.

Instruments for Preparing Cavities.—The process of excavating cavities for the plastics is often unduly complicated by the use of too many instruments. In general, small cavities of all kinds are best prepared with the drill, large ones with chisels and excavators. All small cavities not too long or shallow are most easily and quickly prepared by round or rose drills, which give it the shape demanded by the spheroidal tendency of amalgam. Cavities in hard teeth, which are so destructive on burr drills, should be opened up with spear-pointed drills, as these can be readily sharpened. Undercuts in all the small and most medium-sized cavities can be made most speedily with round-edged wheel burrs. Most medium and all large cavities, crown and proximal, are most readily opened up with the chisel used by hand-pressure or mallet-force, the first being limited or controlled by placing the thumb on the end of the tooth, and the latter being confined chiefly to the molars.

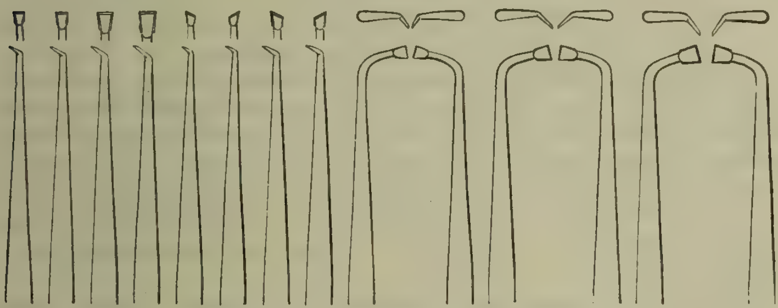
The necessary instruments for preparing proximal cavities consist of a chisel to remove accessible enamel; a chisel-excavator to remove the enamel and dentine along the cervical wall; a spoon-excavator to scrape and cut out quickly and safely the carious and softened dentine; and a round-edged excavator to groove the palatine and buccal walls. But grooving these walls is seldom sufficient for anchorage; it will frequently be necessary to carry the cavity into the fissure between the cusps, aiming *to divide the strength of the operation between the tooth and the filling.* Care must, however, be taken lest this anchorage between

the cusps, at least in bicuspids, be carried too far or cut too deep. These fissures are most readily prepared with the drill.

The instruments just named secure the most *systematic* and *rapid* as well as the *safest* and *least painful* operating.

Two or three shapes and sizes of chisels are sufficient. A sharp spoon-excavator meets the requirements of "speed, comfort, and safety" in preparing cavities. The decay can often be removed, *when the enamel-walls are first properly trimmed away*, by two or three cuts, and that, too, with the least risk of exposing the pulp. The chisel-excavator devised by the writer is to the cervical wall what the ordinary chisel is to the labial or buccal and palatine walls. The angle, size, thickness, and edge of the blade admit of the smoothest and most effective cutting in a small space, without passing into the cavity or slipping off against

FIG. 148.



the gum. Fig. 148 shows this instrument in its various shapes and sizes for all proximal cavities in the upper and lower teeth.

WHEN AND WHERE THE PLASTICS ARE INDICATED.—Judicious selection of filling material is based on the quality of the teeth, the extent of the lesion, and the nature of the oral fluids. As a general rule, the plastics should be used in all teeth except the hardest up to the fifteenth year, amalgam being used only in the molars, and sparingly even in them; gutta-percha may be used to a greater extent, especially in proximal cavities; and zinc phosphate should be used in the cuspids and incisors. When amalgam is used during this period it should be in combination with other materials, it being particularly well adapted to completing all large fillings much exposed to attrition.

Perhaps the most general rule that can be given for the use of amalgam is this: *Keep it out of sight.* This rule, applied to the majority of cases, would confine it to sixteen teeth—viz. the twelve molars and the lower bicuspids. It is, however, not unfrequently indicated in the upper bicuspids, especially when the buccal walls can be lined with the oxychloride of zinc; and it is sometimes the best material that can be used in the distal cavities of the superior cuspids. Amalgam is specially adapted to the molars, owing to their position, their size, and the relatively greater force of attrition to which they are exposed. When poorly calcified or badly decayed the molars and bicuspids are often best filled by combining gutta-percha and phosphate of zinc with

amalgam, the first being used near to or under the gum, the second occupying the greater portion of all large crown cavities, and the last being used to protect the others from the force of mastication and the action of the oral fluids.

When a "submarine" filling is indicated, as in extensive cervical and buccal lesions in the posterior teeth, in particular when the cavity, with or without an "annex," extends far down beneath the gum, amalgam, meeting as it does the greatest number of requirements, is *par excellence* the material to use. But both gold and amalgam sometimes fail at the cervical wall. There cervical lesions are anticipated or prevented and removed by what is by some called "guarding." When gold is used this wall is protected—first, when the cavity extends beneath the gum, by amalgam; second, by tin when this can be kept from sight; third, by soft gold, which in the better class of teeth answers every purpose. In very soft teeth when amalgam is used this wall should be "guarded" by gutta-percha, which tapers to an edge, so that but a small extent of surface is exposed.

Of all plastic materials, amalgam is the best adapted to repairing the lesions that too frequently occur at the margin of gold fillings in the proximal cavities of molars and bicuspids. It not unfrequently becomes necessary to repair amalgam fillings in the same location. An undercut is not always necessary when attaching new to old amalgam. Clean and scrape the surface of the latter and rub on some fresh amalgam mixed very thin, when the repair or filling can be completed in the usual way.

Dr. S. G. Perry recommends repairing the marginal groove around amalgam fillings with gold. This is undoubtedly an excellent method: besides securing to the dentine the preservative properties of amalgam, it prevents or removes, in some degree, discoloration of the enamel, and gives to that tissue whatever benefit may arise from the contact of two metals in the same cavity.

Not unfrequently the most difficult point to attain in a filling or tooth is strength. The weakest teeth when largely filled with amalgam or anything else are the bicuspids. In many cases the best way to strengthen these is to weaken the force they are required to bear by removing the inner cusp, as recommended by Dr. D. D. Smith. By cutting off the inner cusp, and so filling that the strain of attrition will be brought against the amalgam, the durability of such a tooth can be permanently secured.

It sometimes happens that bicuspids are so weakened that they are split through between the cusps. As might have been expected, the "plastic-fillers" claim that the divided parts are united in the strongest manner by the use of amalgam. A bolt made of gold wire has generally been used for this purpose; and it is needless to say that it is stronger than two or three times the same thickness of amalgam passing almost or entirely through the tooth. The use of amalgam requires such a large amount of drilling and cutting that the tooth is not only weakened, but is liable to become unsightly from discoloration, for amalgam to have any strength must be largely composed of silver.

A weak or divided crown is most effectually strengthened or united

by enclosing it in a Richmond cap-crown. This can be applied in all cases except when the tooth is too sensitive to permit its sides to be ground parallel (which is an essential), so that the upper border of the cap can be passed under the free edge of the gum and *fit closely around the neck of the tooth.* This cap cannot often be used farther front than the second bicuspid.

The uniting of loose and separated roots by the use of amalgam Dr. Flagg regards as "the great dividing-line between gold and plastic dentistry." This is "a field in which the marvels of plastics seem fairly to revel." It is true that, so far as such roots can be made to serve a temporary and a more or less permanent purpose, amalgam has the field to itself as a material for uniting them. Separated roots can always be united, and loose ones not unfrequently; but in many such cases, especially when the looseness is caused by or associated with extensive injury to, or destruction of, a portion of the peridental membrane, such roots had better be removed and the space occupied by a tooth or teeth attached to the usual base-plate, or, better still, attached to other roots that are or can be made strong and healthy. When the looseness results from causes which can be readily removed, and there is a fair prospect of these roots becoming firm again, they should be united by loops of platinum wire which is barbed on the corners and thickest at the ends, and then passed into the enlarged pulp-canals and secured by packing amalgam around them.

This "great dividing-line," on which the "wrecks of former days" are supposed to make their "last stand," is certainly the limit of patching or bracing up tooth-structure of any kind or amount. Beyond this there is a field in which neither plastic nor any other kind of dentistry can effect anything by plastering and patching shells and snags, except injury to the surrounding parts.

Amalgam for Filling Roots.—In view of the fact that amalgam has been recommended for everything that properly or improperly comes under the head of plastic dentistry, it seems remarkable that it has not been utilized as a root-filling. The writer does not wish to be understood as recommending it for this purpose, but would merely suggest some points of comparison. It is true that amalgam has been used in this way, but only incidentally, as when setting certain artificial crowns. It is superior to gold in these respects: it can be carried to the end of the canal with more ease and certainty and with less risk of being forced through, and it can be more readily adapted to all parts of the canal. Both metals are equally liable to be saturated with the fluids and gases of putrefaction, and both are equally difficult of removal when occasion requires. The only thing that can be said in favor of cotton as a root-filling is that it leaves a "line of retreat" in case of trouble, but it may be said that cotton more than any other substance makes the "line of retreat" necessary.

Recent investigations have only emphasized and enforced the lessons of experience in respect to the necessity for treating with antiseptics and disinfectants and the advantage of a solid root-filling. The experience of the most successful dentists seems to justify the inference that an intelligent application of the resources of dental therapeutics will dis-

pense with cotton and retreating through "taps" made and marked for that purpose. Cotton is a good root-filling, provided it be dipped in oxychloride of zinc before being packed into the canal.

Crowning.—Nothing better illustrates the absurd extreme to which it is advised to carry the use of amalgam than the proposal to utilize it to replace bicuspid and even cuspid crowns, the tendency being to reduce dentistry to filling and patching up shells with one material composed almost entirely of base metals. Such a crown, though shaped ever so artistically, is unsightly at the best, and while it may have reasonable strength of attachment, and may not permit redecay, it will not prevent splitting of weak roots any more than other bandless or collarless crowns, and is at best but a poor substitute for a properly-attached porcelain crown.

Heretofore, there has been too much of a tendency, after repeated failures in filling, to extract the root or roots, apparently because, as the crown could not be saved, the root should be destroyed. When from poor structure or worse dentistry a crown must be lost, the root, when possible, should be saved and utilized as a base for a single tooth or partial denture. As a rule, success with this kind of work is more easily attained than with filling, and depends essentially, as regards the crown, on *strength* and *security of attachment*, and as regards the root on *prevention of splitting* and *redecay*.

The statement has been made that in "pivoting" amalgam has wrought a most radical change. It has been, and is still, used to some extent, as in the Bonwill and Flagg "pivots;" but phosphate of zinc is used almost exclusively in the better class of crowns, such as the "collar crown" and the Richmond, as well as in almost all bridge-work. The author of *Plastics and Plastic Dentistry* recommends attaching with amalgam natural crowns which have been broken off during mastication or by accident. It is safe to say that a crown so frail as to be broken off by the force of attrition would, when replaced, make an unsightly and not very durable operation. As the tooth is necessarily devitalized, and a large part of its interior is replaced by the amalgam, its color in a short time would be anything but presentable.

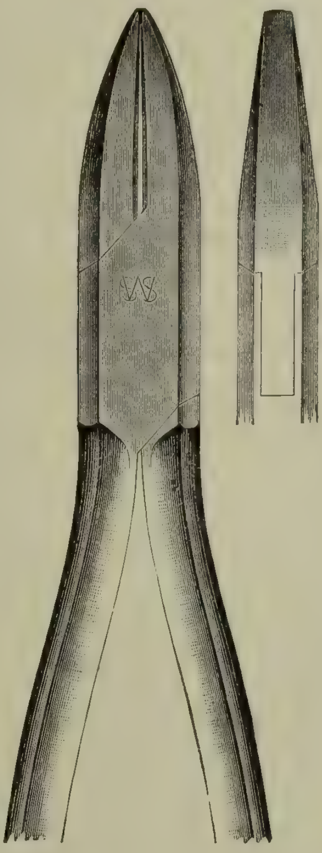
Gold and Amalgam Combined.—Dr. D. D. Smith's theory and practice exemplify that gold and amalgam may touch in the same tooth and cavity, not only without detriment, but with decided advantage. He so combines gold and amalgam as to secure the preservative properties of the latter without its objectionable appearance. Gold in crown cavities in contact with amalgam in proximal cavities in the same tooth is always better than either metal alone. The easy adaptation of amalgam in inaccessible positions, notably along the cervical wall of proximal cavities in bicuspids and molars, is one of the strongest points in its favor. In use, about one-fourth of the cavity should be filled with amalgam, which should then be allowed to harden a day or two. With quick-setting amalgam, however, and the use of the matrix, the gold can be built in at the same sitting.

Mixing Amalgam.—There are several methods of mixing amalgam—viz. in the hand or in a mortar, or by shaking in a glass tube or long narrow bottle. The first method is very common, but neatness is not

one of its strong points; besides, it is not certain that it may not sometimes be injurious. The mortar "mix" is probably the best, though the mixing is generally completed in the hand. The mode of shaking the filings and mercury together in a tube or bottle was introduced by Mr. Thomas Fletcher, and has doubtless very decided merits. After being shaken till thoroughly united, the mass is pressed into pellets by the use of a cylindrical matrix. When a mortar is used, either glass or porcelain will answer the purpose, but the former should have the glazed surface removed by grinding.

In mixing amalgam it is a matter of importance to know the exact amount of mercury required. Much has been claimed for the method of weighing the filings and the mercury; but, by a strange inconsistency, some who claim most for this method use pliers to remove the surplus from at least the last portions of the amalgam. Again, it has been asserted that it is impossible to remove a surplus of mercury, and yet most amalgams can easily be pressed too dry for easy working.

FIG. 149.



The amount of mercury required varies with the number and kinds of metals composing the alloy, and with the required degree of plasticity—a point which is determined by the position and condition of cavities and teeth. An excess of mercury is to be avoided, for the reason that compressing with pliers always involves a loss of metals with the surplus, and the loss may be considerable in gold and platinum alloys. An excess of mercury is avoided by gradually adding the filings until the proper consistency is attained. An objection to the method of weighing the filings and mercury is found in the fact that it is impossible to mix most amalgams as dry as they should be for completing the last fourth of the filling; so that compression with pliers must still be resorted to to secure the necessary dryness; which makes weighing a waste of time. The mixing or kneading of amalgam must be thorough, and continued until a distinct *crepitation* is heard. This sound is most marked in alloys composed largely of silver. The most thorough mixing is demanded in alloys containing platinum. Washing amalgam has fallen into disuse, it being found impossible to remove all moisture from the mass or to so pack it as to exclude the oral secretions. By some it is claimed that washing prevents discoloration by the re-

moval of metallic oxides, but it is questionable whether moisture does not increase rather than diminish the amount of oxidized matter in the filling.

Almost all fillings should be completed with amalgam compressed as dry as can be easily worked with or without warm instruments. No matter how amalgam is mixed, there will always be some excess of mercury, which is removed by placing the mass in chamois skin and either twisting it or pressing it with pliers; the twisting making the material dry enough for general purposes, the pressing preparing it for completing the filling. Dr. Flagg's "wafering" pliers (Fig. 149) are especially adapted to the latter purpose, having ample size and strength and having no angles or edges to cut the chamois skin.

When the location of the tooth and the cavity is favorable a quick-setting amalgam is to be preferred for the entire filling, and in all cases for completing it, for the reason that such an amalgam is not so liable to be affected by moisture or damaged by the force of attrition.

The balling-up, which is most marked when tin predominates, is overcome by working the amalgam almost or entirely granular with warm instruments. In this way crown-cavities at least can be filled, but there is a limit beyond which dryness destroys the density and durability of this material.

A varnish or lining in connection with amalgam is often indicated, as it acts as a packing, and, if adherent to the cavity-walls and insoluble, gives perfect protection to the dentine. A recent writer advises the use of a varnish consisting of equal parts of dammar and sandarac dissolved in ether. This is better than either alone, and makes a lining which has a good color and is comparatively insoluble and durable.

Instruments for Plastic Filling.—The easy and proper working of the plastics requires but few instruments. It should be the aim of the operator to have the smallest number of suitable shapes and sizes. Plastic instruments consist essentially of two shapes—the round and the flat; the first being for packing the larger part of the filling, and the other for completing it. The terms "ball" and "sickle" suggest, but do not correctly describe, these shapes, for the former should seldom be round, while the latter is often required to be straight.

The face of the round end is either convex and smooth or flat and serrated. But, as with "gold-builders," neither entire flatness nor extreme convexity is desirable. Even the ball-burnisher, unless very small, is improved by having its face slightly flattened, so that a greater extent of surface is brought to bear on the material or filling. Though an entirely flat and deeply serrated surface is less objectionable for the plastics than for gold, such a surface is improved by being slightly convex, for the reason that the material is more readily and certainly packed against the walls.

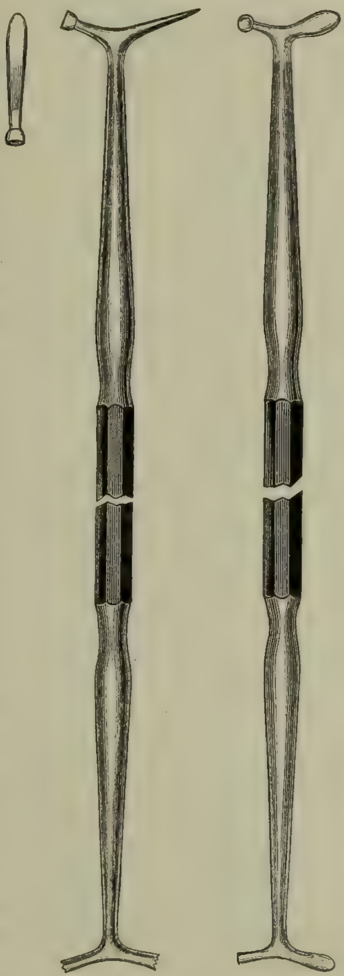
There are a number of sets of plastic instruments—most of them being specially designed for amalgam—each set containing from six to twelve points, which are nearly all modifications of the shapes just mentioned. The obvious objection to having so many separate points is loss of time—a matter of no small consequence when working the quick-setting plastics. To remove this objection and to have everything

needed in as compact a form as possible, the writer has combined all the essential points in two double-ended instruments. These eight points include not only those that are essential, but almost all those that are used for any kind of plastics (Fig. 150).

These instruments consist of three packing-points of graded sizes, the faces of two being flat and serrated, the other round and smooth; two ball-burnishers, one spherical, the other slightly flattened; three lanciform burnishers of different sizes, the largest being transverse to the shank. The small, smooth packing-point can also be used as a minute burnisher.

Fig. 151.

Fig. 150.



There is, however, another form of instrument especially suitable for filling crown and small proximal cavities in the superior molars and bicuspids. This instrument, which somewhat resembles several others, is the invention of Dr. Thomas Fry. It is a carrier and plugger combined, and, among other things, it aids in preventing the dropping of the amalgam. It consists essentially of a cylinder which fits accurately around the end of the plugger, and rests at the rear against a spiral spring, which projects its front end about one-eighth of an inch beyond the plugger-point, thus forming a receptacle for the amalgam (Fig. 151).

Inserting Amalgam Fillings.—After being dried, all cavities should be saturated with some antiseptic or germicide. This applies particularly to all immature teeth and to all cavities in which some softened dentine has been allowed to remain. Cavities in very soft teeth should not be saturated with any strong escharotics, such as chloride of zinc or carbolic acid in full strength. After an interval of about five minutes the cavities should be again dried. The rationale of this treatment is found in the fact of the presence of micro-organisms in softened dentine. It will often be necessary, in addition to this

treatment, to varnish the cavities in children's teeth and in soft teeth generally. The medicines used most frequently for this purpose are oil of cloves and dilute carbolic acid. The varnishes usually applied are balsam, copal, mastic, and sandarac. Dryness is a great advantage, if not a necessity, with all the plastics, but it is essential to the durability of the zinc plastics, and even, to some extent, to that of amalgam; for, besides giving better results generally, perfect dryness tends to limit discoloration. As a rule, however, when plastics are most decidedly indicated dryness is often difficult and sometimes impossible of attainment; but, fortunately, it is just in such positions that discoloration of the filling or tooth is least objectionable. For molar cavities—buccal and proximal—which extend beneath the gum nothing is so preservative as an amalgam which is composed largely of silver and in which there is about 5 per cent. of copper. Dr. Flagg's "submarine" amalgam is specially designed for this purpose, and, though it darkens teeth almost to blackness, it is a most pronounced tooth-conserving material.

In filling the cavities just mentioned the use of the rubber dam is almost always out of the question; nor is it always possible to use a napkin to any good purpose. After such cavities are saturated for five or ten minutes with carbolic acid or a 25-per-cent. solution of chloride of zinc—the latter more decidedly preventing exudation from the gum—they should be washed out with tepid water, dried quickly with a large pellet of spunk or cotton, and the amalgam be put in promptly in large pieces and packed at once into place. As soon as the moisture reaches the amalgam the packing should cease, the mouth be rinsed with water, and then bibulous paper be used freely and quickly on the surface of the filling, when the packing can be continued as before. In cases where the flow of the saliva is very abundant the amalgam must be packed literally under water, which should displace the oral fluids in the cavity. But even in such cases much can be accomplished by leaning the head to one side, then quickly drying the cavity and putting in the filling in one or two large pieces. When the gum hinders free access to the cavity, or even when the cavity is much below its border, a pledget of cotton saturated in dilute chloride of zinc should be pressed into the cavity and be allowed to remain a day or two. At the end of this time the gum will not only be out of the way, but the escharotic effect of the zinc chloride will effectually prevent any exudation from the gingival surface. Tincture of iodine can often be used with good effect for the same purpose at the time of inserting the filling.

As a rule, dryness can be secured in all the teeth by the use of the rubber cloth, though it is often sufficient, particularly in the upper teeth, to use a napkin. If at all difficult to apply, the rubber should not be used in the cases of very young, very sensitive, or very nervous patients.

Dryness is almost as important for some time after as during the insertion of a plastic filling. The plastics that harden by crystallizing —amalgam and the preparations of zinc—should be kept dry from twenty to forty minutes, and the latter should be varnished.

The matrix—a device for which the profession is indebted to Dr. Louis Jack—is a most valuable appliance for filling proximal cavities. With amalgam it does not require the same thickness or rigidity or to be so firmly fixed as for gold. It should be accurately adapted to the tooth, and in cases where it cannot be readily withdrawn when the filling is in place, it can be left till the amalgam is entirely hard.

Amalgam should be divided into pieces corresponding to the size of the cavity or undercut to be filled. The grooves or undercuts should be filled, not (as has been recommended) with the softest portions of the mass, but with the dryest, so that there shall be no excess of mercury to prevent close adaptation.

The pieces of amalgam are conveyed to the cavity with pliers or on the packing instrument. All serrated ends can be used for this purpose, either by having the serrations "amalgamated" or "loaded" with platinum. With unsuitable instruments the dropping of the pieces of amalgam while filling the upper teeth is often as great an obstacle to easy and rapid working as are the oral secretions when operating on the lower teeth. Dropping of the pieces while crushing and packing can be controlled or prevented by having as broad an instrument as the cavity will freely admit. The end of the instrument should be very slightly convex, as a perfectly round end tends to force the material from the cavity. The napkin should be always arranged to catch the pieces which cannot be prevented from dropping. By pressing the napkin closely around the cavity the pieces can be held in place while they are packed.

Amalgam is packed into the cavity in three ways: 1, by pressure; 2, by tapping; 3, by malleting. If it can be shown that a sudden impact on amalgam, as in malleting, forces the slight excess of mercury to the centre or face of the filling, then the two latter methods, which differ more in degree than otherwise, have much to recommend them. But it is more than probable that sudden force or excessive pressure drives the surplus mercury against the parietes of the cavity, where it can be of no possible benefit, but must rather be a detriment. When, however, no mercury can be forced from the amalgam, these methods are doubtless all that can be desired. The first method, pressure, is the one most commonly used, and it is especially adapted to proximal and buccal cavities.

The surface of an amalgam filling should always have a "hard finish." This is attained by using a "white" or "facing" alloy, and pressing the mass quite dry just before packing. Removing all excess of mercury is second in importance only to the original composition of the alloy. For some years the writer had been in the habit of using Lawrence's alloy for the larger part of molar cavities, and then finishing with any of the so-called "white" amalgams. For the latter purpose Flagg's "facing," containing, as it does, silver in excess of tin, as well as gold and zinc, is no doubt the best in some respects; as, for instance, hardness, permanence of shape, and edge-strength.

Finishing.—The careless habits often attributed to plastic dentistry nowhere appear so conspicuous as in the finishing of amalgam fillings. Many such fillings have nothing that could even by courtesy be called

a finish; and next to no finish is such a one as can be given while the amalgam is soft or only partially hardened by drawing the end of a pine stick back and forth or up and down over the surface of the filling. This pine-stick finish seems to the writer to be detrimental to hardness and edge-strength, while it certainly leaves a comparatively rough surface, with all that that implies, including a decided tendency to discoloration.

Amalgam fillings, as a rule, cannot be completed at one sitting; for, even though composed of a quick-setting material, no filling can be given the best finish in one or two hours. Two or three days being allowed for hardening, the work can be completed on crown and buccal fillings by grinding with finishing burrs and corundum points, and on proximal surfaces by the use of sandpaper disks and emery strips; afterward in all cases polishing with pumice. There can be no good reason given why amalgam fillings should not be as smoothly finished, if not as finely polished, as those of gold. Even with a perfectly smooth finish occasional repolishing will be required on surfaces not exposed to attrition.

Zinc Phosphate.

Zinc phosphate, as prepared for dental purposes, consists of a powder and a fluid or crystals. The powder is calcined and pulverized zinc oxide; the fluid is glacial phosphoric acid. Experience has shown the crystal acid to be generally the most reliable, since it does not deteriorate so readily as the fluid. Most of the German cements, which are certainly rock-like if not always durable, are prepared with the crystals, while the American zinc phosphates are mixed with fluid acid. As far as the writer's knowledge or experience goes, the best American cements show equal durability with those of foreign manufacture, and the fluid acid is certainly very much more convenient in use than are the crystals.

It was at first supposed, as in the case of the oxychloride cements, that zinc phosphate would supersede amalgam. The fact of its solubility in the oral fluids makes it inferior to the latter material in the essential of durability. The permanence of this material will vary with the chemical characteristics of the oral fluids, which it is well-nigh impossible to control for any length of time. Constant good health, absolute cleanliness of the teeth, as well as the faithful use of suitable mouth-washes, are always required to give greatest durability to fillings of zinc cements. And it may be said that whatever prevents the material from deteriorating will prevent fillings from disintegrating. But it is more than probable that no method of preparing or keeping this material can show it to be as good after a year or two as it was at first.

Like oxychloride of zinc, this material seems at first, at least, to have been somewhat disappointing; but for soft teeth, in particular those of children, most operators find it, if not entirely satisfactory, decidedly useful and valuable. The solubility of this compound in the oral fluids has not always been sufficiently recognized, and the

fact that it is readily disintegrated by alkaline secretions seems to be often overlooked.

The durability of fillings of this compound is sometimes surprising. A filling made from the best quality of this cement will, under favorable conditions, usually last two or three years, but not a few fillings have been known to last from five to seven, and even ten, years. The writer has seen in the teeth of foreign students fillings of German cement in crown cavities that after eight years' wear were but slightly cupped in the centre. The writer is not aware that these cases are exceptional or that his views on this subject differ from those of many others. It is needless to say that gold fillings would have done no better, while amalgam could not have made as presentable an appearance.

Uses of Zinc Phosphate.—It is used for three very important purposes—viz. for "inside" and "outside" work and for setting crowns. It is equally adapted to "outside" work in soft or badly-decayed teeth or for filling the greater part of all large and deep cavities when the filling is to be completed with gold or amalgam. When used alone as a filling, it finds its most important use in the front teeth of children, where it should be allowed to remain until about the fifteenth year. It is equally suitable for bicuspids and molars, except when the cavity extends to or beneath the gum, where gutta-percha better withstands the disintegrating fluids. When it is combined with gutta-percha—the latter substance occupying the upper third of the cavity—these two substances show their tooth-conserving properties to the best advantage, resisting as they do the two destroying forces—those of attrition and of chemical agents. All cavities, notably those in children's teeth, should be protected from the action of the phosphoric acid by a varnish lining covering the dentine surface, and which should be allowed five to ten minutes to dry before introducing the filling.

Zinc phosphate is valuable for filling the greater portion of large and deep cavities, to save time and labor, and to serve as a non-conductor and as a solid base when gold or amalgam is to complete the filling. Though very easily introduced and kept in place in crown cavities while the metallic filling is being built in, there is often difficulty in retaining it in proximate cavities after the undercut has been made. It can, however, be retained with certainty while the gold is being introduced by the following method: Take, for example, a central incisor; excavate as usual, and cut and drill the grooves and pits, and then fill the cavity from one- to two-thirds full of the cement, which while setting should be removed from *the anchorage in the cervical wall*, and for some distance also from the grooves in the labial and palatine walls; now build in the gold until it extends about halfway down across the cement, which is thus securely held in place while its lower edge is being removed from the rest of the anchorage. In other words, the lower half of the cement is securely held by the anchorage while the upper half is being covered by the gold. This method can be used in all proximate cavities.

The density of zinc phosphate makes it a good root-filling, though its toughness and stickiness make it difficult to introduce. It is, however,

Fig. 152.

inferior to oxychloride of zinc, not only in easy-working qualities, but in antiseptic and disinfectant properties, which are important characteristics of a root-filling.

For setting crowns and attaching bridge-work zinc phosphate has almost entirely superseded other materials, gutta-percha being now used very little for that purpose; but amalgam is still used, and is no doubt the best material for the Bonwill and Weston crowns. But for the Richmond, the "collar crown," and other crowns of this kind zinc phosphate is, *par excellence*, the material. A collar or ferule crown must be set with a cement which offers but little resistance to pressure, can be readily forced through a very small aperture, and will set promptly and solidly without shrinking; all of which conditions are met by this compound.

For setting crowns and attaching bridge-work, zinc phosphate meets all requirements, except that it sometimes sets too rapidly, and is often not a little difficult to introduce into the canals. The too rapid setting is controlled by placing the mixing slab as well as the cement bottles in ice-water for a few minutes. It is introduced into canals to anchor crowns and bridge-work, so as to prevent withdrawing the material or confining the air, by the following method: The root being properly treated, the canal should be enlarged toward the palatine side, undercut or grooved with a wheel burr, and then thoroughly dried; the cement, mixed rather thin, is now carried up along the palatine side on a tapering piece of orange-wood, thus driving out the air, which would otherwise act as a cushion to prevent the ingress of the cement.

Mixing and Manipulation.—To prepare this cement for filling, take about equal parts of the powder and fluid. When in crystals the acid should not be melted by heating the bottle, but some of the crystals should be taken out with a small spatula made of orange-wood and placed in a silver teaspoon or in one made of platinum—the latter preferably—and carefully and gradually melted over the flame of a spirit-lamp, then placed on the usual glass mixing-slab, and allowed a few moments to cool. No crystals should be returned to the bottle, and the stick used for taking them out should be carefully scraped before being used again. The powder is worked into the fluid gradually by rapid circular movements of a large spatula (Fig. 152), the movement being occasionally reversed. When all the powder is worked in that the liquid will take up, the mixture should be quickly scraped from the slab, rolled into a ball with the fingers, and promptly placed in the prepared and dried cavity. When the cavity is deep or has overhanging walls care must be taken to avoid confining the air, by using small portions of cement at first, then complete the filling

with larger pieces, leaving a surplus to be trimmed off afterward. When the cavity is very large make two or three mixes. At least ten minutes must be allowed for setting before finishing, as shaping or cutting the cement while setting interferes with the crystallizing process, causing a tendency to softness just where the filling should be hardest. Zinc phosphate, when mixed thick, as it should be for permanent fillings, often sets very quickly—too quickly for proper working. When it sets too rapidly, as it often does in warm weather, cool the glass slab in ice-water for a few minutes and then dry off the moisture. In all cases the cavity should be perfectly dry, and appliances for preventing ingress of moisture must all be in place before the cement is mixed, and dryness should be maintained until the filling is finished and varnished. After from ten to twenty minutes have been allowed for setting, the filling can be properly shaped by cutting and trimming off with emery tape; then varnish, and allow a few moments for drying before removing the rubber dam or napkin.

The following is Prof. Peirce's method of making zinc phosphate: The oxide of zinc should be packed into clay or black-lead crucibles, and placed in a fire until it has been reduced in bulk fully one-third, and has a good yellow color. This then is to be pulverized in a mortar, iron or Wedgewood, until it will pass through a fine bolting-cloth—about No. 80—which yields an impalpable powder ready for use. The glacial phosphoric acid—the best and perfectly clear—is dissolved in water, pure or filtered, then boiled until it is reduced to almost the consistency of a syrup and is clear. If boiled too much, it crystallizes on cooling; if too little, the cement has no tenacity and crumbles.

Oxychloride of Zinc.

Oxychloride of zinc has been used for filling teeth for about twenty-five years. It was brought to the notice of the profession by M. Sorrel, by whom it had been used for some time for other purposes. As with most of the plastics, many who were ignorant of its true nature came at once to the conclusion that the ideal permanent filling had appeared, while not a few who had not learned or had ignored the fact of its solubility in the oral fluids, rebounded as usual to the opposite extreme and considered it worthless. Several years ago the merits and demerits of this material were much discussed, and the reports of successes and failures varied as widely as the expectations of the several writers or experimenters.

As regards plasticity, appearance, and preservative properties, as long as the material itself is not disintegrated it is all that could be desired; but, like the other zinc plastics, it lacks the essential element of indestructibility. It was formerly supposed to have wonderful therapeutic effects on the pulp, quickening it to action while living and embalming it when dead. Being an antiseptic, it has the latter effect in no small degree; and when the pulp is not devitalized through its escharotic action on the fibres of living matter, this compound does to a most marked degree cause hardening or recalcifying of softened dentine. It is, however, remarkable for what a length of time the notion was held

that oxychloride of zinc is a remedial agent to be applied directly to the delicate pulp-tissue. As might have been expected, when it was used in this way as a capping it destroyed the pulp almost as promptly as arsenic, but with less after-effects on the adjacent parts. The supposed weakness or inertness of a 25-per-cent. solution of chloride of zinc when mixed with the oxide is not sustained by experience.

This material certainly has some excellent qualities for special purposes, such as obtunding sensitive dentine, filling pulp-chambers and root-canals, and lining thin walls when amalgam is to form the bulk of the filling. It owes its obtunding power to its escharotic properties, and its plasticity and antiseptic qualities especially adapt it to filling canals which have contained putrescent pulps.

Like all remedies or materials that have such positive properties and produce such decided effects, oxychloride of zinc must be used with caution, particularly in soft teeth or deep cavities. As has already been said, this compound owes its obtunding power to its escharotic property, and is therefore a most radical remedy, removing sensitiveness, in soft teeth at least, by destroying the vitality of a layer of dentine. If it were always self-limiting in its action, it would doubtless be as safe as it is effective.

When any of the zinc plastics, particularly the oxychloride, is used in soft teeth or near the pulp, the dentine surface of the cavity should always be varnished with mastic, sandarac, or any other of the varnishes recommended for preventing destructive irritation.

When oxychloride of zinc is used as a capping the pulp should be protected against its escharotic action by a small disk of asbestos felt-foil, as recommended by Professor C. N. Peirce, or by mixing a small quantity of the oxide of zinc with a drop of the oil of cloves or dilute carbolic acid, and placing it over the exposure, as first suggested by Dr. J. S. King.

As already stated, this compound is at once the most perishable and preservative of all filling materials. But it is perishable only when used as an "outside" filling or under a material that leaks; and it is so preservative that decay has never been known to occur under it.

Oxychloride of zinc has been long used for filling pulp-canals. It is better in some respects for this purpose than zinc phosphate, not being so sticky and allowing of thinner mixing and slower setting. Its objectionable porosity is more than counterbalanced by its antiseptic and disinfectant properties. The upper half at least of the canal is best filled by winding a very small piece of cotton on a probe, dipping it in the cement, passing it up to the end of the canal, and then withdrawing the instrument little by little and packing in the filling.

Gutta-percha.

Gutta-percha is the dried milky juice of a tree. It has originally a light-red or almost flesh color. It is particularly noted for being a perfect non-conductor of electricity.

It was first used for filling teeth in 1847. It was soon seen to be so well suited to this purpose that its use became general. In 1848

appeared Hill's stopping, which was "a mixture of gutta-percha with quicklime and powdered quartz and feldspar." Dr. Hill believed—and not without good reasons—that his material in many cases could take the place of gold.

Dr. Flagg says that nearly all the better grades of gutta-percha stoppings were, and are, composed mainly of gutta-percha and oxide of zinc. Of course different makes differ, and the same makes at different times. It has not unfrequently been asserted that very few or none of the various makes of gutta-percha of the present day are equal to those used several years ago.

Gutta-percha has been graded according to the degrees of heat required to soften it. The "low-heat" variety softens between 140° and 200°; the "medium grade" ranges from 200° to 210°. Both these grades being below 212°, they should be softened over warm water. The "high" is sufficiently plastic at from 216° to 230°. This is softened on a metal or porcelain slab. Direct contact with the flame of a lamp should be avoided, as by this the gutta-percha is heated too rapidly, may be partially carbonized, and swells or disintegrates readily. The "low heat" is good for canals either dissolved or softened. The "medium," being tough and resisting, is good for filling in general.

Gutta-percha has some good qualities as a material for filling carious cavities. What especially recommends it for this purpose are its properties of being non-conducting and non-irritating both as regards caloric and electricity. It has also some objectionable attributes. Its being inserted when warm and the fact that it contracts while cooling make it a leaky filling; but as it is a perfect non-conductor, this leakiness does not usually cause redecay, though it occasions a discoloring or "clouding" which makes the teeth unsightly.

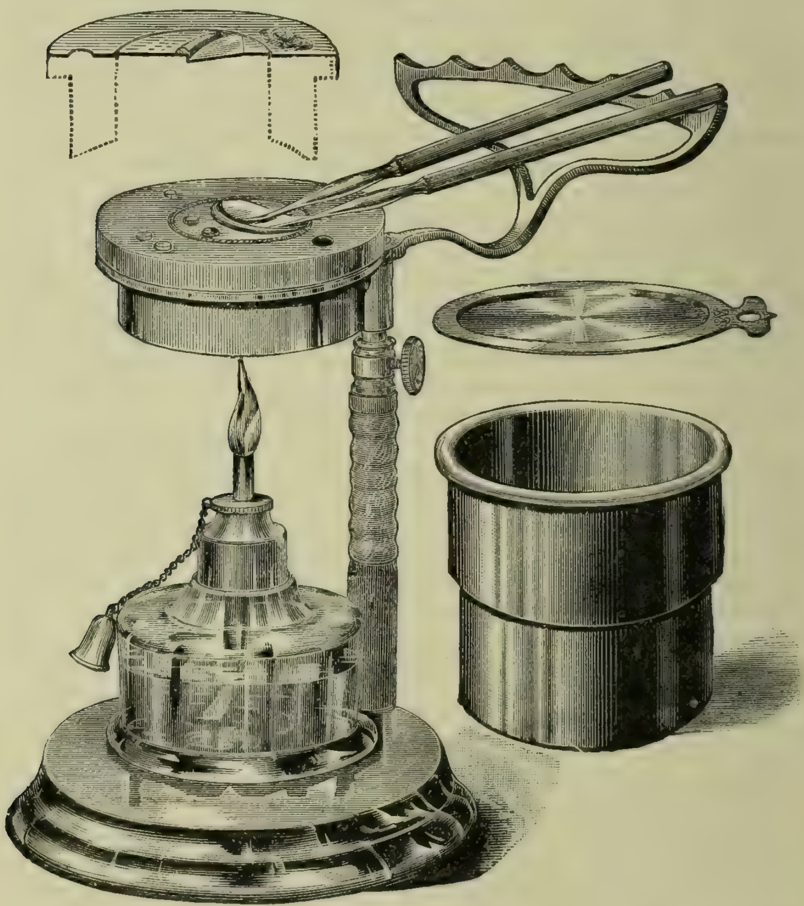
It might be inferred that its non-conducting and non-irritating attributes would make it one of the best materials for capping pulps: in point of fact, it is really one of the worst materials for this purpose, since under it the pulp is always more or less disturbed and often destroyed. Some account for this by its supposed elasticity under tight packing. However this may be, it seems to the writer that the elasticity of a material which contracts could have no such effect, and that the real cause for the death of pulps may be seen in the commonly-observed phenomena of the softening and swelling of the surface of gutta-percha fillings. It seems to have been overlooked that the moisture from the pulp, as well as that from the tubuli of a very soft tooth, has the same effect on the internal surface of a capping as the fluids of the mouth have on the external surface of a filling.

Though gutta-percha is disintegrated to some extent by moisture and chemical agents in saliva, it is chiefly destroyed by attrition. Hence it should be used where it is least exposed to the wear of mastication. Its resistance to disintegration and its tooth-conserving qualities appear to the best advantage when its use is confined to buccal cavities near or under the margins of the gum, and when it is utilized to cover the cervical walls of proximal cavities in bicuspids and molars. When of a good quality and properly worked, it will in some cases stand the force

of attrition from two to four years. When it is "cupped" by wear it, of course, can be repaired by heating the worn surface and applying new material. Since gutta-percha is destroyed chiefly by attrition, as much as possible of the enamel-walls should be allowed to remain, so that while the filling preserves the dentine, the enamel will protect the filling. But as this substance gives little or no support to the enamel-walls, these must not be left too thin. As to shape, the cavity should be largest within, and the enamel-walls should be at right angles with the tooth-surface.

Gutta-percha is generally used where dryness is most difficult to obtain, yet complete absorption and exclusion of the moisture, if not always essential, are always a great advantage. The rubber dam should

Fig. 153.



be applied when that is practicable, otherwise napkins and absorbents should always be used. Sometimes the walls may be dried by a careful use of warm air, so that the gutta-percha will adhere. A gutta-percha

and instrument-warmer (Fig. 153) is very desirable, so that all can be heated at once. Not only warm, but cold and oiled, instruments are required to avoid drawing the material out or away from the walls. Put the material in piece by piece, and do the final filling and finishing toward the margins. A nice finish can be given to a gutta-percha filling by a pellet of cotton or a piece of tape moistened in chloroform.

Gutta-percha has been highly recommended as a root-filling, and it has several qualities which make it very useful for this purpose. It is used either in the shape of cones of a size suitable for the case in hand, or it is used in solution, being dissolved in chloroform. The cones can be softened slightly, either with heat or by dipping in ether just before they are inserted. The use of cones is indicated when the canal has been reamed or drilled out, or when the apical foramen is abnormally large, as this material, even when protruding through, is non-irritating. Its disintegrating is not so easily controlled. Gutta-percha in solution is especially adapted to small, flat, or crooked canals. The cones are particularly useful for filling the upper fourth or fifth of the canal in crowning or bridge-work. There is, however, a better method of filling canals than with gutta-percha in any form : it is with wood. After treating, the canal can, if not too crooked, be reamed or drilled out, and in all cases *accurately measured*, and its exact length indicated on the tapering wood, which must be slightly larger than the canal, so that it can be driven into place, but not through. Before being driven in the wood must be saturated in carbolic acid or in equal parts of carbolic acid and iodine. When an abscess exists or occurs in such cases it is treated through the fistula if it is direct, or through an opening made through the process for the purpose.

ELECTRO-CHEMICAL RELATIONS OF STOPPINGS TO THE TEETH.

By S. B. PALMER, M. D. S.

The following considerations must be regarded as constituting a new chapter in the department of operative dentistry. Indeed, only within the last decade has there been any attention paid to the electro-chemical relations of filling material to tooth-structure, the existence of such relations having been at first generally ignored.

Having been requested to record my views upon this subject in a standard work on Dentistry, I offer the following pages, prefaced by a brief history of the movement which has culminated in at least a practical recognition of the adaptation of special materials to definite conditions of tooth-structure. The records of many failures led me to the belief that the preservation of teeth was as yet but a much-coveted result not fully realized. Comparison of views revealed the fact that others, some of them celebrated for fine operations, shared the same disappointment, thus demonstrating that the law of preservation had been violated, and a principle overlooked which in filling teeth determined the success or failure of the operation. The object of my investigations has been to improve my own practice and to enable me to contribute such information as might aid others in a like undertaking. Even twenty years ago discussions showed that tin-foil possessed antiseptic properties which did not pertain to gold for arresting decay in frail teeth. Cases which had received treatment from an economical standpoint, fillings entirely of tin or with tin foundations, covered in the most exposed situations with gold, well attested the truth of this position. Amalgam, too, which at the time was thought beneath the notice of most leading dentists, practically supplied needs in cases where gold could not be utilized. The merit of amalgam, owing to my strong prejudices against its use, was with me slow to be recognized. The exalted estimation in which gold as a filling material was held, together with the high praise awarded the operator who could successfully manipulate it, left a wide gulf between a practice conducted upon a gold basis and one which, according to the professional standard, involved, both in material and want of skill, all that was considered inferior and deteriorating. Notwithstanding this distinction, facts made it apparent that different materials were specially adapted to different conditions of the teeth, and that no one material could be considered universally and unqualifiedly "best."

At the outset this theory was new and the science of it little understood. The teachings were antagonistic to established practice, and not in accordance with the popular idea of proper filling of the teeth. Its presentation to the profession provoked severe criticism. I, however, took no part in personal controversy, but firmly trusted to the teachings of science; and to-day there is harmony, practice has become modified, principles are recognized, and this article has been solicited for future reference.

Dental progress appears to be the outcome of empiricism: practice first, facts second; and lastly science to explain the harmony between practice and facts. Unfortunately, skill, reputation, and remuneration were formerly all in favor of the "good old way," in such degree that scientific investigations and conclusions were ignored, and even pronounced degrading, when they conflicted with established practice. As a result of observations and experiments extending through a number of years I gave my conclusions in a paper entitled "Chemical and Galvanic Action upon the Teeth and the Materials used for their Preservation," which was read before the Dental Society of the State of New York in 1874. Subsequently, and by official request, several other papers bearing upon the same subject were presented at the meetings of this society. Discussion soon made it apparent that the doctrine, to some degree, limited the use of gold as a filling material, and also gave undue prominence to plastic fillings, which was sufficient to render the subject objectionable and unpopular. Such was the estimation in which the theory was held three years after its presentation, at which time it enlisted the interest of Prof. J. Foster Flagg, who asked from me all that had been written upon the subject, soliciting also co-operation from Prof. Henry Chase, and subsequently requesting aid from Prof. Henry Morton and Prof. M. B. Snyder, scientists, and Messrs. Eckfeldt and Du Bois, metallurgists and assayers at the U. S. Mint, Philadelphia. This organization was called the "New-Departure Corps," and gave to the dental profession "Plastic Filling and the Basal Principles of the 'New Departure,'" in a "creed" and address presented by Prof. Flagg before the New York Odontological Society in November, 1877. Both the theory and practice were so widely different from the teachings and belief of that day that much earnest discussion was the result: my claims, however, were comprised in the enunciation of the doctrine that "failure in operations is mainly due to incompatibility of filling material with tooth-bone;" and I had but one object in view—viz. progress in operative dentistry, and the desire that it might rest upon a scientific foundation. So far as possible, the following is an effort to arrive at facts and principles and to so trace the connection of cause and effect as to predetermine results, and thus aid in the diagnosis of conditions for filling teeth.

All our observation and experience teaches that in the universe regularity, uniformity, law, and order prevail; we never even allow for caprice or uncertainty. Although we could possibly conceive that natural laws might be reversed, our confidence in their stability is almost unlimited. We show confidence when we act upon the principle that "*Under the same circumstances and with the same substances,*

the same effects always result from the same causes." This is a "universal" law, drawn, however, from less than universal experience; but it is, so far as human observation goes, a firm conviction, a rule of undisputed accuracy, by which we may find laws from facts and causes from effects. In applying this rule to practice, observation shows that the work of many operators in many cases has stood the test of more than twenty-five years and is still faultless, while other operations made by the same hands have failed in less than one-fourth that time.

It should be one of the first lessons taught in operative dentistry that the insertion of any filling material which is a good conductor of the galvanic current introduces an element of electrical disturbance as true to law and as positive in results as when a copper or carbon plate is immersed in a cell containing the other elements requisite for producing galvanic currents. This disturbance must be proportionately for evil, so far as tooth-preservation is concerned. Whatever may be the result, all is in accordance with natural laws, a knowledge of which would greatly aid the operator in applying the material best calculated to secure favorable results. It is unwise to claim the superiority of any material upon the ground that "in the majority of cases it is all that could be desired." In this respect gold would, in the opinion of many, stand first, but I think that with the same line of reasoning amalgam would come in for quite an equal credit; but, as I have said, this is an unwise basis for estimating superiority. The true thing to know is, What are the conditions and circumstance requisite to produce the happiest results with any or all of the materials with which teeth are filled? Success or failure is the result of law; conditions and combinations determine the ends. All the knowledge which I desire to impart has doubtless been attained by empirical practice, but this process is a slow method of arriving at facts, to say nothing of the many failures and sacrifices necessary to obtain conclusions.

Observation and practice teach that teeth of normal structure and density, when properly filled with gold, may last a lifetime. Unhealthy or abnormal secretions, lodgment of food, lack of cleanliness, excessive use of acids, etc. generally lead to secondary decay. Aside from these agencies, there are two causes of secondary decay that should not be overlooked: first, a deficiency of those mineral elements which in a degree render dentine a non-conductor; and second, defective manipulation of gold, which admits moisture between the filling and the walls of the cavity. The last-named condition brings the most perfect tooth under the same law and subjects it to the same destructive agencies as the first-named; consequently, the one illustration will equally meet both conditions. Also, in regard to the electrical disturbances caused by metallic fillings, the same principle is involved in all of them, though differing in degree. Gold is taken as a basis, because as a filling material it is of the greatest importance; also its action upon tooth-structure is the greatest. As this article is limited to the relations of stoppings to the teeth, no effort will be made to discuss the causes of dental caries in general. Rich contributions to dental literature have recently been received upon this very important subject which conclusively point to the action of the acid products of fermentation upon the dentine and other

tissues of the teeth as the most active agent in the causation of dental caries. We accept the statement, and upon this foundation present our conclusions relating to the action established by the introduction of metallic stoppings. These are that, through the agency of galvanic decomposition of food and the organic constituents of tooth-substance, there is an increase of acids above that which would occur with non-conductive fillings. Let no one suppose that *direct* galvanic currents, such as are formed in the mouth, decompose teeth of normal structure by true electrolysis. Ice and many salts are poor conductors, consequently are not electrolytes in the solid state; some change must occur before decomposition takes place. A change does occur in teeth subjected to the action of acids, which removes the non-conducting phosphates and carbonates; the remaining organic matter is a conductor, and like organic compounds is decomposed by the galvanic current, which is a powerful agent in chemical decomposition of binary compounds, especially the fluids of the mouth and the food which finds lodgment between the teeth. Acids eliminated by such decomposition react upon the lime constituents of the teeth, and thus promote secondary decay.

The primary and secondary stages in the process of decay, so far as the action of acids upon the lime salts is concerned, are probably the same, but its process in the formation of the acid, as well as the quantity produced, admits of a distinction which I wish every interested reader to clearly understand What we denominate primary decay may be classified as simple chemical action. The profession is to be congratulated upon the recently-published contributions of Dr. W. D. Miller of Berlin, Germany.[1] Dr. Miller has enjoyed unusual opportunities for prosecuting the line of study in which he is engaged. The many recorded experiments fully attest the perseverance and labor necessary to arrive at the conclusions he has offered the profession.

It affords me pleasure to quote from the writings of Dr. Miller as a foundation upon which to advance the doctrines embodied in the "Electro-chemical Theory." In his early writings Dr. Miller criticised and condemned the theory set forth in this connection; controversy was deemed not in order, and the case still rests upon its merits. It is proper, however, to say that Dr. Miller's conclusions were drawn from experiments made under conditions which could give only results opposed to the theory in question. I can see no lack of harmony in the two lines of study; both tend to dental progress and the preservation of teeth; they sustain to each other about the same relation as do the primary and secondary electric currents; although distinct, yet they are related. Dr. Miller, after minutely describing the experiments and methods adopted as a basis for his conclusions, says:

"Having established upon an experimental and scientific basis the fact that caries of the teeth is, to a certain extent, the direct result of the action of the acid products of fermentation upon the tissue of the teeth, followed, particularly in the case of the dentine, by the action of the ferment-organisms themselves upon the decalcified tissue, it becomes a

[1] *Independent Practitioner*, vol. v., 1884: "Fermentation in the Human Mouth, its Relation to Caries of the Teeth." (See Vol. I. pp. 791 *et seq.* of this work.)

matter of the first importance to determine, first, by what means we may counteract the action of the acids or prevent their production; second, by what means we may save the already decalcified dentine from complete destruction. Evidently, there are three methods by which the desired end may be partially attained."

The same methods apply equally well to *secondary decay*, and would have been given in substance in relation to the action of fillings upon the teeth; I give credit and quote the methods: "1st. By repeated, thorough, systematic cleansing of the oral cavity and the teeth we may so far reduce the amount of fermentable substances in the mouth and the number of ferment-organisms as to materially diminish the production of acids. This is so self-evident that it needs no further comment. 2. By the repeated application of alkaline substances we may to a certain extent neutralize the acids before they have acted upon the teeth to any considerable degree. 3. By a proper and intelligent use of antiseptics we may destroy the organisms themselves, or at least render them inactive. It is this method which is especially applicable in the second stage of dental caries (*i. e.* the stage which follows the decalcification), and to which we will here give exclusive attention. We must, however, constantly bear in mind that by whatever method we proceed, a previous thorough cleansing of the teeth is absolutely indispensable.

"There is no known solution, alkaline or antiseptic, applicable in the human mouth, which will penetrate between the teeth in sufficient quantity to have any appreciable effect, or to the bottom of fissures and cavities when these are filled with food. Therefore, before all antiseptics or alkaline washes come the toothbrush, toothpick, and floss silk."

The subject before us starts from this point, which is scientifically far in advance of the teachings of former years. Whatever theory is assumed as accounting for the acid products, the process of production is simply chemical. The presence of a metallic filling under favorable circumstances adds a new element or factor for the increase of acids, and the result is *electro-chemical* action. To illustrate by a fact: If a proximal cavity in the mouth of a young person, one which has given no trouble whatever, be loosely filled with gold, care being taken not to disturb the decayed matter, the dentine will in a few days become so sensitive that excavating for filling is an operation to be dreaded. Again, the observer may recall to mind the condition of dentine on removal of leaky gold fillings or in the operation of excavating decay adjoining gold fillings. This induced or increased sensitiveness is the result of electrical disturbances well known in electrical science, and may be distinctly classed as a well-known electro-chemical law.

It is to be presumed that the reader understands the science of galvanism in general; therefore we mention the elementary facts and principles only as they relate to oral electricity or may help to explain the latter. What we call a galvanic current is only a modified form of electricity. If we take pieces respectively of zinc and silver and place them in the mouth, and separate them slightly with the tongue we have constructed a galvanic cell, established a current, and set up decomposition of the saliva. Simple as this arrangement may be, its action

involves the principles of the more elaborate cell commonly used for mechanical purposes.

We will, however, get more distinct ideas of galvanic action by considering the essential elements of a battery of the simplest form. If we immerse two conductors of electricity, like platinum and zinc, in a liquid like dilute sulphuric acid, and then connect the two metals by pieces of wire above the fluid, a current of electricity is evolved by the reaction between the zinc and the fluid, the current flowing from zinc to platinum. The wires which conduct the currents from one element to the other are called electrodes, and the one from the platinum is the positive electrode. Zinc is generally used for the positive element, because it is convenient and cheap. The negative element in a battery may be composed of carbon or metals according to the fluids used.

The arrangement above described is constructed for the purpose of obtaining the best results or strongest current possible with the elements and fluids used. The same principles are involved in lower forms of batteries, where the organic constituents of tooth-structure make up the positive element, while a filling of any conducting material serves for the negative element. The decomposing effects of the current is in proportion to its strength; feeble currents require time in proportion to their weakness; thus, effects which might be produced under favorable circumstances in a few months, by insulation or other retarding influences may be prevented or delayed many years. While the principles are the same in the mouth and in the mechanically constructed cell, the objects sought are quite the reverse. In the cell the current is the energy sought; in filling teeth it is the one thing to be avoided. Let it be remembered that galvanic decomposition is called electrolysis; a substance which is decomposed is an electrolyte; and the termination of the conductors from the battery are called electrodes. Fluidity is essential to the working of a battery, and this element is always found in the oral cavity; even more, saliva is an unstable fluid which is readily decomposed. Substances which in a solid state are insulators, to galvanic currents become conductors, and are also subject to decomposition, when moist or in a liquid state. Dentine when dry is a non-conductor, but in the condition in which it is always found in the mouth it is a conductor, not only by reason of the moisture in the dentine, but from its organic constituents as well. Both the fluids and the animal solids may be decomposed by the galvanic current.

To avoid criticism, it is essential that we fully understand the difference between primary and secondary decomposition by the galvanic current. By this we mean, on the one hand, electrolysis direct from the primary current, or, on the other, decomposition resulting from reaction of substances eliminated upon the electrodes or surrounding fluids. It is this secondary action which decomposes many of the acids, salts, and tooth-substance. The decomposition by the direct current depends upon the quantity of electric fluid passing, while the secondary action depends on the nature and quantity of the agents set free by the former. "Thus, hydrochloric acid has no effect on gold, but when by electrolysis its chlorine is evolved against a gold electrode, chloride of gold is formed. Another feature of decomposition must be remembered—

viz. that the current is increased or diminished according to the distance between the positive and the negative elements; for instance, in solutions of uniform strength the current varies inversely as the square root of the distance between the plates: the distance varying from 4 to 1, the current would be as 1 to 2. This must be considered: in operations in the mouth the same law governs. A filling of gold in absolute contact with amalgam would produce no sensible current; the action would be limited to the plate alone, the same as when the poles of a battery conveying a current are grasped in one hand; separation produces sensation. The least separation of two fillings of opposite metals, like gold and amalgam, produces the strongest current. Most intolerable effects arise from fillings of this nature so situated in a tooth or in occluding or adjacent teeth that in mastication the metals are alternately separated and brought in contact, thus inducing polarization and depolarization, shocks being produced at each depolarization. There can be no fixed rule to determine the exact space to observe between fillings. We are seldom required to do two fillings electrically opposed at the same time; better by far use the same in both. When two fillings are required of opposite metals, experience leads me to be governed by the conditions determined while excavating the cavity. Take, for illustration, proximate cavities in molars and bicuspids. If the dentine is sensitive, particularly if the patient is less than twenty years of age, it is unwise to insert a gold filling opposite to amalgam at a distance less than one-sixteenth of an inch. By varnishing the walls of the cavity an amalgam filling may be risked somewhat nearer."

The one condition to be observed is this: If there is no sensation while excavating for filling, by the use of varnish or gutta-percha solution either gold or its opposite, tin or amalgam, may be inserted as though the materials were one. If the tooth is sensitive, fill temporarily with oxyphosphate or gutta-percha until the sensitiveness is removed, rather than incur the risk even of a much greater space. From the fact that meat-fibre lessens the space or closes the circuit at every meal when that article constitutes a part of the food, the toothpick must in such cases be resorted to in order to restore quiet. Again, the current is opposed to the natural process of deposition of lime salts, so that sensitiveness is often increased rather than diminished.

As a matter of interest, the galvanometer shows that a gold filling cannot be so separated from an amalgam filling in the mouth, even in the opposite jaw, as to avoid a current. This when very feeble of course does no harm; still, the fact exists in proof that normal dentine in the mouth is a conductor of the galvanic current.

From observation and upon authority we may assume that decalcification or decomposition of the lime salts of teeth by acids is the first process of decay. We also know that acids are present in cavities, fissures, or pockets where food finds lodgment for the space of a few hours. We understand that cavities must be filled in a manner to exclude food and fluids, in order to avoid the recurrence of decay. As before stated, this stage of decay is purely a chemical affinity of acids for alkalies.

Here we introduce the first principle of the so-called electro-chemical

theory, taken from a well-known fundamental law in electrical science. A rod of iron placed in a vertical position, one end resting upon the ground, when tested by a delicate compass-needle will show polarity, positive above, negative below; reverse the rod, the upper end will yet be positive and the lower negative. The solution of this phenomenon is: The atmosphere in its normal state is electro-positive, and by the laws of induction, which are well known, certain bodies exposed to it become polarized. It must be borne in mind that an electric state is not a fixed condition, but relative, varying according to attendant conditions.

Metals suspended in fluids obey the same laws: the polarity of course is determined by the relations of the metal to the liquid; the upper end may be positive or negative according to conditions. Again, if a wire be suspended in a liquid between two electrodes through which a galvanic current is passing, it will become polarized by *induction*, without touching either electrode. This principle of induction and polarization is a positive law in electro-galvanism, as truly at work in the oral cavity as in the laboratory. It is a fundamental principle to be observed in the choice of materials for filling teeth, and affords scientific reasons for the appearance of secondary decay at the cervical walls in proximity with gold plugs.

Before making the application to the oral cavity I would compliment W. Kencely Bridgman, L. D. S., Eng., on being the only writer, to my knowledge, who has advanced kindred views upon this subject. In the *Transactions of the Odontological Society of Great Britain*, 1861–63, also 1869–70, may be found three papers by Dr. Bridgman—viz. "On the Absorption of Bone and Dentine," "Pathology of Dental Caries," and "On the Electro-chemical Action of Metallic Substances upon the Teeth." The first two papers mentioned have no special bearing upon the present subject, as they relate to the more general electrical activities at work in the human system. In *this* respect Dr. Bridgman runs the lines and sets the stakes so far in advance of common observation as to be unheeded except by the scientific observer. It is not my purpose to *repeat* the act of advancing new theories, nor to be placed in a position compelling me to defend the same against the criticisms sure to follow. However, in honor to Dr. Bridgman, whose views are in harmony with my own conclusions, I will quote a few sentences in relation to absorption of bone which may aid those who are at present so studiously engaged in the effort to solve this most difficult problem. Dr. Bridgman, after most clearly defining the action and principles involved in a galvanic cell, says:

"The absorption of soft substances not undergoing decomposition becomes a mere question of solution and imbibition; but hard ones, as bone and dentine, have first to be decalcified before the primitive cartilaginous material can be dissolved and absorbed. In this respect the process of absorption is simply the reverse of that of formation. With respect to the removal of the hard element, there can be little question of electrical influence. If a piece of sulphate of lime (or any other insoluble salt) be placed in water under the wire of a galvanic battery, it will be decomposed, the lime appearing at one of the electrodes and

the sulphuric acid at the other. If the current be reversed, the lime and sulphuric acid will change places. This reversal of the current, causing this change of place, *constitutes the key* to the alternating or reciprocating action of growth and absorption in the system. The introduction of the lime during formation and growth is a physical, not a vital, effect, and not only physical, but also electrical, in arrangement. Take a piece of amber or vulcanite; warm it by friction and rasp it over a vessel of tepid water; the particles falling upon the water will arrange themselves in certain clearly-defined formations manifestly not the result of capillary attraction, and indicating only their electro-polar condition. This experiment of course shows simply the nature of the agency employed in *arranging* the materials used in organic construction. . . . . Therefore to set up absorption in a bone which is negative it is only necessary to induce an electro-positive condition of the adjoining parts."

Now, let us apply these principles to the mouth in relation to the action of fillings upon the teeth. As previously stated, fillings of metal so situated that one portion comes near the gums and another near the crown of the tooth are always polarized, that portion nearest the gums or neck of the tooth being positive.

Thus far, we have credited Dr. Bridgman with such experiments and conclusions as we could use to illustrate the subject before us. Dr. Bridgman, it seems, was engaged in this work at or about the same time as myself. He perhaps commenced two or three years earlier. This fact, however, was unknown to me till about eight years later.

The following quotation will most clearly show that, scientifically, his conclusions have no practical applications for the advancement of operative dentistry. He seems not to have grasped the true teachings of his experiments, or, being cognizant of the fact, had sufficient wisdom not to bring upon his head the denunciations which such a declaration would most certainly have invoked. The following is the quotation referred to:

"An amalgam filling in the side of a tooth having one edge near the gums, generates acid at the latter point. This is due to polarization, since, as we have seen, a body of metal having its two ends exposed under different circumstances becomes polar; and in proportion as there is any substance to be acted upon by the oxygen, so is the amount of chemical action regulated. Thus a metallic plug in a proximal cavity, as in the external basal area of the molars, will have the cervical edge continually wet, while the upper part may be comparatively dry; and therefore it will assume the polarized condition. With the entire range of metals and metallic compounds the question of electro-chemical action is one only of degree, for the one cause affects them all more or less. In this respect gold is unquestionably very much the best of metallic fillings, as being the least oxidizable; but even with gold certain precautions are essential to success. The one indispensable condition is *that there shall be no lodgment for moisture* at any point of the circumference of the filling." Thus we see in this declaration popular prejudice ruling over scientific investigation.

It would be an act of injustice to an able writer to dismiss the subject

with this allusion to a single error, and not give the valuable suggestions which follow as to methods for overcoming the difficulties connected with all metallic fillings. Dr. Bridgman says:

"It is thus seen that all metallic fillings possess certain inherent defects; and the question then arises whether these defects are insuperable or whether they admit of remedy. One of two remedial proceedings is indicated—*to prevent polarization*, or *to permit the effects of polarization being reflected upon the dentine.* The former is not by any means difficult, but it requires a thorough knowledge of the laws under which it occurs in order to adopt the proper provisions required to meet ever-varying conditions. *Insulation*, however, is one of the means by which we prevent polarization, and it is also the remedy for attacks upon the dentine. Either gutta-percha, waxed tissue-paper, allotropic sulphur, or osteo-plastic forms an admissible insulating lining for a cavity."

Modern practice now recognizes the benefits to be derived from the insulation of gold fillings, and improved methods and materials are in use for this purpose. Still, we admire the pioneer work done by Dr. Bridgman.

We now have before us one recognized and substantiated fact relating to the incipient stage of dental caries: that is, that acids first dissolve the lime elements from the enamel and dentine. Dr. Miller, as we believe, scientifically accounts for the presence of the corroding agencies, but, if we rightly understand his writings, does not recognize the potent agency of the galvanic current in promoting decay around metallic fillings. I, however, fail to discover any want of harmony in the views expressed. By experiments, artificial cultures, and aid of the microscope Dr. Miller is able to reproduce, classify, and note the workings of the various low forms of organisms which dwell in, if they do not produce, the acids ever present during the process of decalcification of tooth-bone, which is a chemical process.

By well-known electric laws and by the aid of the galvanometer we see that gold introduced into or placed in contact with such acids becomes polarized, that decomposition of the fluids and food-substance is the result, and that an additional amount of acid is the consequence.

We speak of gold comparatively: other metallic fillings act in proportion as they stand upon the scale of oxidation and conductivity. The ideal filling would be neutral; that is, one which, if a conductor, would produce no current and have no agency in the decomposition of the matter usually found in fissures and cavities in the teeth. Unfortunately, we have no such metallic filling. The law governing positive and negative elements is such that with fillings which are positive to the fluids and matter already mentioned decomposition is the result; the filling fails, acid results from such decomposition, and thus the lime salts are dissolved. It is hardly possible to present this subject in more distinct and comprehensive language than is found in a paper by Dr. George Watt of Ohio, written for the Ohio State Dental Society in 1878. Having already described the construction and working of a galvanic battery, we quote only such passages as will make clear the subject of electrolysis or decomposition by the electric current, or, in other words, show the distinction between chemical and electro-chemical action:

"A liquid may be able to conduct galvanic currents while it holds in solution a number of binary compounds. The current will decompose them in the ratio of their chemical equivalents. For example, in the mouth is found water, chloride of sodium, chloride of potassium, and at the same time ammonia, sulphuretted hydrogen, etc., each containing but two elements, and each therefore subject to electrolytic decomposition.

"Thus far, reference is had to true electrolysis, true galvanic decomposition; but the chemical action thus liberated must not be overlooked, and this secondary action must not be confounded with electrolysis, as has been far too common. Very much of the chemical results of galvanic action is due to the affinities of the elements thus set free, which, being presented in their nascent state, have the increased energy incident to that condition. If a tooth is in any degree disintegrated or corroded as a result of galvanic action, the phenomenon is due to this secondary action, and never directly to electrolysis.

"I regard the subject as greatly simplified when this is clearly understood. Confusion of thought has resulted from an unprofitable discussion of the direction of the galvanic current in the battery and along the electrodes. By confining our thought to the battery alone, we gain clearness of view. All galvanic action within the mouth is analogous to what occurs here. To aid the memory let us examine the action within the ordinary battery. If a strip of pure zinc and another of copper are placed in a liquid composed of sulphuric acid and water, and these strips are allowed to touch each other or are united by an intervening conductor, something takes place. The oxygen of the water unites with and corrodes the zinc; but when water yields oxygen a corresponding equivalent of hydrogen is liberated. This gas, being but slightly, if at all, soluble in water, and unable to unite with either of the metals, escapes in bubbles, but only at the surface of the copper if the battery is perfect. In the list of elements oxygen and hydrogen are at different points of the electric scale. Oxygen is more electropositive than any other. But, as we have seen, oxygen goes to the zinc in the battery, and this is because the zinc is positive, or in an electric state opposite to that of the oxygen. And the hydrogen goes to the copper, because it is negative, a state opposite to that of the hydrogen. Hydrogen is probably a metal. Now, remember that all the metals take the same direction when separated from the corrosive elements by electrolysis, and the corrosives, such as chlorine, sulphur, fluorine, etc., follow the example of the oxygen.

"This brief statement, retained in the memory, affords a key to almost any supposable case of electrolytic decomposition. To remember the direction of the positive current in the galvanic circle we need only recall the fact that the zinc or corroded metal is positive. The current passes from this through the liquid to the copper or uncorroded metal, along this to the electrode or connecting metal, and back to the zinc. The negative current, equal in power and velocity, traverses simultaneously the opposite direction. Circumstances being equal, the quantity of electricity set in motion by a galvanic battery is directly in proportion to the surface excited. A pure zinc plate four inches square will

give off sixteen times the quantity afforded by a similar plate an inch square. Another elementary fact often ignored is that the decomposing powers of batteries, other things being equal, vary inversely as the square root of the distance between the plates. When the plates are one inch apart the decomposing power is twice as great as when they are four inches, and four times as great as when they are sixteen. And, in like manner, when they are a fourth of an inch apart the power is double that of one inch, and is increased fourfold when they are but a sixteenth of an inch. An imperceptible distance (apparent contact) is many times less than a sixteenth of an inch, yet the increase of power is governed by the same law. The practical electrician sees daily illustrations of this on account of the impurities of the zinc of commerce. Small particles of iron are often diffused throughout the zinc, which, with the latter metal, form an infinitesimal series of minute batteries of wonderful decomposing power, as is manifested by the great abundance of bubbles caused by the escaping hydrogen. This is an illustration of true electrolysis as good as any known to electro-chemical science. The ultimate elements are separated in accordance with their relative electric properties, each going to the metal whose electric state is the opposite from its own. Now, suppose we place a plate of impure commercial zinc in a liquid containing not only water, but chloride of sodium, sulphuretted hydrogen, and ammonia. Here are four binary compound liquids capable of conducting galvanic currents and acting on the particles of both the zinc and iron, but with the greater energy on the zinc. The water will be electrolyzed, and it is easy to remember that its oxygen goes to and corrodes the zinc, while its hydrogen goes to the iron and escapes in gas-bubbles unless it there finds something with which to combine.

"But the salt is also electrolyzed: its chlorine, being a corrodent, follows the oxygen, while the sodium goes to the iron. Sulphur goes with the oxygen—its hydrogen of course to the iron. When we reflect that these corrosive elements are brought to the zinc in obedience to electric attraction rather than to chemical affinity, we can readily see that their corrosive action need not be, and is not, all spent in corroding the zinc. When liberated they are free to obey the laws of affinity. But it is well known that nascent chlorine takes hydrogen from almost any compound containing it.

"The disinfecting and bleaching properties of chlorine are mainly due to this fact. It will therefore take hydrogen from water, forming hydrochloric acid, and this at the zinc. Ammonia, composed of hydrogen and nitrogen, if present, is also electrolyzed; and hydrogen being always electro-positive, of course the nitrogen has to go to the zinc; and, as it is there in its nascent state, finds oxygen also nascent; combination takes place, nitric oxide being first formed, which in the presence of air and water is rapidly changed to nitric acid. It is on this principle only that the white variety of dental caries is ever found as a result of galvanic action within the mouth. . . . . When two metals are placed in the mouth, and one is corroded by the buccal fluid, if they are not in contact, and if there is no other conductor connecting them than the fluid itself, the metals assume opposite electrical states, but no current is estab-

lished and decomposition of the fluid does not take place. The condition is that of static electricity. But if the metals touch each other, or both touch the mucous membrane of the mouth, a regular circle is developed, and decomposition occurs in proportion to the quantity of galvanism thus set in motion. A gold plug and one of any base metal may constitute such battery; and let us suppose these plugs are in adjacent teeth and in close contact with each other at a given point, or both in contact with the membrane at the necks of the teeth; the binary compounds in the buccal fluid must be decomposed; but how? Water and soluble chlorides are present in all mouths. Then, of water the oxygen, and of the salts the chlorine, go to the base metal, and the hydrogen of the water and the metals of the chloride go to the gold.

"But we have already seen that nascent chlorine takes hydrogen from compounds containing it; hence hydrochloric acid must be formed at the base metal. And this is why we so often see the most common variety of dental caries about the margins of the base-metal plugs, this decay being always the result of the action of hydrochloric acid. . . . . Hence when the hydrogen reaches the gold, it takes chlorine from compounds containing it as promptly as itself is captured by the chlorine at the other side of the battery. But by this combination we have hydrochloric acid again; and this is why we so often see the same variety of decay around the gold filling. At the other side much of the force of the chlorine, as well as of the acid, is spent in corroding the base metals, while neither the hydrogen nor the acid can attack the gold, but all the force of the acid is spent on the tooth; and thus the tooth with the gold plug is in such cases more corroded than that with the base metal. . . . . When a gold plug leaks there is apt to be galvanic action. The organic matter of dentine is a conductor, and in this case represents the corroded or zinc side of the battery. Hydrochloric-acid decay occurs in such cases when the buccal fluids are normal, but when ammonia is present we may have white decay co-operative with it, owing to the formation of nitric acid by electrolysis of ammonia."

We have quoted at length from Dr. Watt, because he has given clearly the process and results of galvanic decomposition of buccal fluids. While he is decidedly opposed to amalgam, like a true scientist he has faithfully recorded the chemical results when he says: "At the other side much of the force of the chlorine, as well as of the acid, is spent in corroding the base metals, while neither the hydrogen nor the acid can attack the gold, but all the force of the acid is spent on the tooth; and thus the tooth with the gold plug is in such cases more corroded than that with the base metal; which leads some to the conclusion that the base metal is the better filling." In which he truly records a scientific fact.

Again, he says when a gold plug leaks there is apt to be galvanic action. "The organic matter of dentine is a conductor, and in this case represents the corroded or zinc side of the battery"—another fact which must soon be recognized in operative dentistry; indeed, is already practically observed, even by some who have disbelieved in the scientific teachings which account for the facts. No one can more heartily rejoice over the harmony which now prevails in practice throughout the profes-

sion than myself. *True science* admits of but one school of practice. Science may be ignored, but the fact remains that *true practice* is a unit and will harmonize with science.

Having in a general manner enumerated the most prominent electro-chemical principles to be observed in filling teeth, I will now give a brief practical summary of the laws to be observed in the operation. Nature shows no favoritism. Good intentions, perfect manipulation, costly material weigh nothing against judicious selection of material for specific conditions of teeth to be filled. Chemical action is the agent to be overthrown. Its action may be suspended and the teeth preserved, or its powers may be extended with opposite results. The filling of a tooth combines or unites the material used with a substance which is composed of an alkaline base, combined with organic tissue, and all bathed in a chemical fluid of no definite composition.

Teeth also vary in structure and resistance to corroding agents. Some teeth are not sufficiently dense to be non-conductors of galvanic currents; secondary decay—by which is meant decay around fillings—is evidence of the fact.

Again, the fluid element to which teeth are exposed, and which in the normal condition is calculated to preserve, too often is found in connection with substances of a deleterious nature taken as food or drink, and thus becomes destructive.

None of the metallic fillings in use can be worn in the mouth without more or less electro-chemical disturbance. All such fillings become polarized, and hold positive or negative relations with other fillings of different metals or to the fluids which are subject to electrolysis, including the organic portion of the tooth which has become decalcified. Such currents are harmless when found in connection with teeth of normal structure, because such teeth are not an electrolyte to the weak currents found in the mouth. Normal secretions also prevent harm from such action. In cases of teeth of ordinary density in connection with normal secretions, preservation with gold fillings may be regarded at present the highest attainment in operative dentistry.

On the other extreme, the following conditions as surely produce unfavorable results: Leaky gold fillings, abnormal fluids, excessive use of acids or alkalies, poorly-calcified tooth-structure, and want of cleanliness. After the calcareous portion is dissolved from the organic constituents of a tooth, the latter becomes both a conductor and electrolyte, subject to decomposition by such currents as may be generated by metallic fillings. All such fillings come under one law in regard to their relations with the substance decomposed, varying of course according to their conductivity and differences in oxidation, ranging from gold to copper amalgam. The latter, by hyperoxidation and deoxidation of copper, refills the decalcified structure with a sulphide, and thus forms an indestructible compound of the same polarity with the plug: thus all galvanic action ceases.

Gold combined with tin, tin alone, and the various grades of amalgams rank between gold at one extreme and copper amalgam at the other; all of which impart to poorly-calcified dentine more or less antiseptic properties, while gold furnishes absolutely nothing. It should be

borne in mind that compound fillings of gold with tin or amalgam produce most decided changes in the tin or amalgam, causing more rapid oxidation, which better answers the purpose as an antiseptic, but which is unsightly. The reason of the increased oxidation is that gold is negative and the other elements positive; by reason of contact the current is confined to the two metals. The chemical action which follows very soon corrodes the baser metal, as oxidation shows, when further action ceases; all of which is in accordance with well-known chemical laws. Fillings of opposite metals may be worn in the same tooth, if separated sufficiently, without discomfort or discoloration; but when the distance does not exceed the sixteenth of an inch, it is far better to connect the two, for reasons already given.

In the use of gold and amalgam fillings in approximate cavities it becomes more difficult to lay down definite rules for the operation. If the following general points are observed, little trouble may be anticipated: Fillings in the same tooth are usually in the crown, the septum being normal tooth-bone or enamel, thus offering great resistance, while in proximal teeth the surfaces of the fillings are arranged in the best possible manner to produce a current. The direction of the dentinal tubuli which lead to the pulps forms a ready circuit through the pulps and nerve-canals. When there is a demand for two fillings of this nature at the same time, both can be inserted of the same material. Cases often occur where it is desirable to insert gold adjacent to an amalgam filling already doing service, or *vice versâ*. If the space is less than the sixteenth of an inch, the condition of the dentine must be taken as a guide for the operation. If the preparation of the cavity is painless, no other preventive is needed than a coat of dammar-sandarac varnish. Gold ought never to be inserted upon sensitive dentine in positions above described, as the disturbance is not apt to abate, as may that arising from thermal changes in ordinary fillings.

The drilling of pits for anchorage is very bad practice where there is any chance for electric currents, as the pits are apt to penetrate the softest portion of dentine, and, being nearer the pulp than other portions of the cavity, when filled with anchor points become conductors, greatly annoying and sometimes even causing destruction of the pulp.

"Guarding" fillings is another method of insulating gold fillings to prevent secondary decay. In the language of another, "guarding is the placing of a material in apposition with the cervical wall of a cavity of decay which shall by its possession of certain physical characteristics act under certain law to prevent, in greatest degree, the recurrence of decay at that vulnerable point." Prof. J. Foster Flagg says: "It is now more than twenty years since I commenced the use of tin-foil, amalgam, and gutta-percha as guard fillings at the cervical walls—not because they were *soft* and could be *more perfectly adapted* to the parietes, but EMPIRICALLY, because I had noticed that fillings made from these materials permitted occurrence of decay less promptly than did gold, even when worked by the best manipulators of that day; not with the avowed intention of removing them when the tooth-structure became thoroughly calcified, but with the intention of *renewing* them when decay should eventually recur, which I knew would probably be

the case at some future time, even though the recurrence should be much retarded. This, which at the time was *empiricism*, has become the strictest following of science."

"In cavities which are accessible, in which dryness can be attained and maintained, in which lining with oxychloride, and final filling with either a single or a combination amalgam is thought to be the proper practice, a guard of gutta-percha is the thing indicated. This should be made as thin as possible consistent with certainty that it thoroughly protects the cervical edge. It may be given bulk in moderate degree within the cavity, and worked to a feather-edge at the cervical margin. It is better that it protrude a little, so that, the lining and final filling having been accomplished and the amalgam having sufficiently set, the 'guard' may be neatly trimmed off with a heated instrument. This ensures nice adaptation, desirable finish, and perfect protection."

While gutta-percha is a fine material for guarding when used as above described, very thin at the cervical border, it is a mistake to apply it in any considerable thickness to make a foundation for either gold or amalgam fillings. The toothpick, brush, or even natural wear, soon cause a depression for the retention and decomposition of food at the very point most liable to secondary decay while the filling proper may seem to be perfect.

In most cases where guarding by amalgam would be objectionable on account of color or galvanic action upon a filling opposite, gold-foil prepared in the following manner answers every purpose without these objections: When the cavity is in readiness for the rubber dam, take a piece of No. 4 gold-foil, one-eighth or one fourth of a sheet according to the size of the cavity or portion to be guarded; varnish it on both sides with the preparation of dammar-sandarac; let it remain unfolded until ready for filling. When dry varnish the cavity, and apply the prepared foil in any form and quantity that the case demands. The gold will work like "putty," without springing; it remains attached to the cavity-walls, and makes an improved foundation for a cohesive-gold filling. It is well to allow the foundation gold to extend or lap over the cervical border; when finishing the plug the excess can easily be cut away with an appropriate instrument.

Insulating metallic fillings is a process generally overlooked, especially by operators who disbelieve in the electro-chemical theory. Empirically, however, many have learned that by lining cavities under certain conditions teeth may be filled and preserved, without which the operation would be questionable, to say the least. Insulating and lining in general practice accomplish about the same object, and will be treated under the one head, *insulation*, adding thereto the lining of cavities to prevent the escharotic action of fillings upon sensitive dentine, and also to maintain color in the walls of the cavity when it becomes necessary to insert discoloring filling material. Teeth are rendered more comfortable, secondary decay is less frequent, and fillings are retained longer with some insulating material between the filling and walls of the cavity, under the following conditions: When the dentine is sensitive or the bone poorly calcified, and when decalcified bone is left in the cavity as a capping for the pulp. Whoever will take the

trouble to varnish dentine in its various conditions, and examine the results with a magnifying-glass, will at once see that one coating of thin varnish occupies little or no space in the cavity, but has been taken up in filling the tubuli and scratches of the instrument used for excavating. My attention was first directed to the great value of a "varnish lining" by the durability of a resinous gum which had been exposed to water and other unknown agencies for centuries. I was given a specimen of petrified wood which was taken from a Western mine some eighty feet below the surface. The specimen resembled Norway pine in grain and appearance. In polishing it for the cabinet there was the odor of resin. A piece was placed upon a red-hot plate, and smoke arose which was followed with flame. When the action ceased the amber-colored streaks between the grains had disappeared, while the siliceous substance which occupied the place of wood-fibre remained in slabs or layers. The gum in this specimen had, like amber, the power of endurance the wood had not, and long ago had given place to the mineral element described: the most interesting and practical idea gained was, that the compound which originally united the gum with the wood—or, in other words, that blending of wood and gum—had also been the medium which still united the mineral grain to the gum. So varnish appears to combine (mechanically perhaps) with soft tooth-structure in a degree like the resin with the wood to resist the action of secondary decay.

My experience with gutta-percha varnish has not been so favorable. It is too soft, it occupies too much space, and very often turns dark, thereby giving to the tooth the color of secondary decay. For the above reasons I seldom use it as a cavity lining or insulator.

It is probable that with this contribution my literary connection with the "New Departure" will be completed, and I leave it with the hope that the work may prove a help to my brother-practitioners and a comfort to suffering humanity.

CALCAREOUS DEPOSITS ON THE TEETH.

By A. W. HARLAN, M. D., D. D. S.

Saliva.

The teeth are constantly bathed with saliva, which is poured into the mouth from three pairs of glands—the parotid, submaxillary, and sublingual. Intermingling with the products of these glands are the buccal mucus, the secretions from the nasal mucous membrane, lachrymal glands, pharynx, and frequently bronchial mucus. Particles of food and cast-off epithelial scales, vibrios, leptothrix filaments, microscopic vegetations, and other foreign matters are in suspension or minute subdivision in this fluid, which has a tendency to render it very variable in the mouths of different people. These changeable components of saliva render it difficult to find two analyses to correspond in minutiæ. The age and habits and state of the bodily health must also be taken into account in finding the components of saliva. The period of the day or night when it is collected, and the additional facts of its being found acid in reaction after long-continued speaking, the presence of aromatic or other odors, fasting, or any physical or mental emotion at the time of its collection, determine to a certain extent its composition. "The solid constituents of the saliva are about 1 per cent., and in 100 parts of solid constituents from 7 to 21 parts are fixed salts, chiefly chlorides, with calcium carbonate and phosphate" (Fownes). "The saliva is an alkaline fluid characterized by the presence of a peculiar albuminous substance called *ptyalin*, which easily putrefies" (Bloxam). I have found the saliva obtained from the mouth of a healthy man aged thirty-four, collected between the hours of 9 A. M. and 4 P. M., a piece of crude rubber being chewed during that time, to contain the following:

Water	995.08
Solid matters	4.92
Epithelium and mucus	1.87
Fat	.04
Mucin and traces of alcoholic extract	1.33
Chloride of sodium, chloride of potassium, phosphates of calcium, magnesium, and lithium, with traces of oxide of iron	1.59
Sulphocyanide of potassium	0.09
	4.92

The subject breakfasted at 7.30 A. M. and lunched at 1.30 P. M., the teeth being brushed after each meal and no food being taken between the meals. The reaction was alkaline.

According to Vaughn, saliva may contain chlorides, sulphates, phos-

phates, sulphocyanic acid, albumen, mucin, ptyalin, bile, tyrosin, leucin, and other accidental substances, besides water.

Frerichs gives the following analysis of the saliva of a healthy man:

Water	994.10
Solid constituents	5.90
Epithelium and mucus	2.13
Fat	0.07
Mucin and traces of alcoholic extract	1.41
Sulphocyanide of potassium	0.10
Chloride of sodium, chloride of potassium, phosphates of the alkalies and earths, and oxide of iron	2.19
	5.90

"The saliva contains, of gases, small quantities of nitrogen and oxygen (the latter in far greater quantities than other secretions), and abundance of carbonic acid" (Frey).

It has not been considered necessary for the purposes of this article that analyses of the secretion from separate glands should be given, or that a monograph on the saliva as a whole should precede the consideration of calcareous deposits on the teeth, as the space is too limited for even a brief summary of what has already been published. An analysis of saliva shows pretty conclusively that the substances which enter into the composition of salivary calculus or dental tartar are present in that fluid in a state of health, and it further teaches that careless or filthy habits, or pathological conditions of the mucous membranes—fever, the eruptive diseases, catarrhs, or other abnormal states—so change and alter the constituents of mixed saliva as to clearly account for the complex substances composing dental tartar.

Normal saliva is alkaline in reaction. The state of opinion pervading the dental mind during several decades concerning the origin of dental tartar is herewith briefly appended.

Dental Tartar.

Bell[1] says: "The formation of a calculous deposit upon the teeth in a greater or less degree may almost be said to be universal. . . . . It consists of a calcareous substance which, when first deposited, is soft, friable, and readily crumbling under the finger, but gradually . . . . acquires a rocky hardness. . . . . The mode in which this substance is produced and the source from which its secretion is derived have been variously stated and explained; but the common opinion, that it is deposited from the saliva, appears, from every circumstance, to be undoubtedly the true one. The saliva is found by chemical analysis to hold in solution the very substances of which the deposition now under consideration is composed. It is invariably found that its accumulation takes place in the greatest quantities exactly opposite to the openings of the salivary ducts. From these circumstances it is, I think, sufficiently evident that the earthy matter of salivary calculus is deposited by the saliva, in which it had previously been held in solution."

[1] *The Anatomy, Physiology, and Diseases of the Teeth.*

Maury[1] says: "Authors do not agree upon the manner of the formation of these various kinds of dental concretions. Without recapitulating hypotheses more or less ridiculous, I will state that the opinion most generally received is that it is produced in part by a pathological secretion of the gums, and in part by a kind of deposit of the saliva and other fluids that moisten the mouth.

"Every one knows with what facility tartar accumulates upon the teeth. . . . . It is observed that persons whose teeth are most liable to such incrustations are of a pituitary, delicate, and mucous constitution, whose mouths are constantly bathed with an abundance of viscid saliva, and whose gums are pale, soft, of a dull red or livid and turgid aspect. Climate also influences this formation, and it is not so frequently met with upon the teeth of persons inhabiting warm or temperate climates as upon those who inhabit marshy and humid regions."

Salter[2] says: "The hard incrustations which collect around the teeth are true calculus, deposited from the saliva, with an admixture of certain organized elements and a small amount of matter derived from the food. . . . . Upon treating tartar with strong acids and alkalies a number of insoluble minute threads are found. . . . . I believe that these indestructible threads are leptothrix fibres."

Harris[3] says: "It is now generally conceded that this deleterious concretion is a deposit chiefly from the saliva, with an admixture of mucus, as the analyses of both these secretions reveal the necessary materials in sufficient quantity to form it. . . . . The conclusion, therefore, appears to us irresistible, that this earthy matter is chiefly a salivary deposit, and takes place in the following manner: It is precipitated from the saliva as this fluid enters the mouth—especially when the secretion is sluggish—upon the surfaces of the teeth opposite the openings into the ducts from which it is poured. To these its particles become agglutinated by the mucus always found, in greater or less quantity, upon them. Particle after particle is deposited, until it sometimes accumulates in such quantities that nearly all the teeth are almost entirely encrusted with it."

Wedl[4] says: "The formation of the adherent deposit upon the teeth may readily be explained. Since the gums are attached to the dental necks, and the extremities of the papillæ upon the gingival borders project slightly, accumulations of the secretion of the gums are the more likely to take place in these localities. This secretion flows downward upon the upper teeth, and accumulates especially in the depressions and grooves of the enamel surface. In consequence of the frequent occurrence of leptothrix in the oral cavity of man, this epiphyte finds a lodgment in the viscid coating containing effete epithelium. The latter, in conjunction with the proliferating leptothrix, becomes saturated with the constantly-secreted saliva, the calcareous salts of which are precipitated in the minutely porous substratum. In this way there is formed a cemented mass which cannot be removed from the surface of the enamel except with the aid of sharp instruments."

[1] *Treatise on the Dental Art.*
[2] *Dental Pathology and Surgery.*
[3] *Principles and Practice of Dentistry*, 11th ed.
[4] *Pathology of the Teeth.*

Bond[1] says: "This substance is deposited from the saliva under certain conditions of that fluid, and is most liberally deposited upon the teeth nearest to the salivary ducts and upon those of the lower jaw."

Tomes[2] says: "The saliva, together with oral and pulmonary mucus, holds in solution various salts, which are precipitated in greater or less quantity on natural or artificial teeth in those situations when the fluids of the mouth remain at rest. Epithelial scales and other extraneous matters that may be floating in the oral fluids or are entangled amongst the teeth become impacted in the precipitated salts, and thus contribute to form the concretion known as tartar."

Magitot[3] says: "In our opinion, the tartar results from a simple deposit by precipitation of the earthy carbonates and phosphates, held in solution in the saliva by favor of the organic matter with which they are combined. At their arrival in the buccal cavity, the principles separating upon contact with the air and with the mucous membrane, the salts insoluble in water are precipitated and deposited upon the surfaces of the teeth."

Taft[4] says: "That it is precipitated from the saliva is a fact so easily demonstrated and so generally admitted that it need not here be considered."

Garretson[5] says: "When the salivary secretions are sluggish the inorganic material, not being held in solution until fairly ejected into the mouth, becomes deposited about the roughened and inviting surfaces of immediately neighboring teeth. A nucleus once formed, aggregation goes on until serious secondary lesions are apt to result."

Coleman[6] says: "With regard to tartar or salivary calculus, which is deposited upon the teeth in much the same manner as are the lime salts upon the sides of a steam-boiler, we may say a few words. Analyses have shown it to be chiefly composed of earthy phosphates and animal matter. It is the latter, doubtless, that gives to most varieties its repulsive odor. The organic matter is, of course, furnished by the mucus and epithelia, also by the leptothrix and micrococi found in abundance in many mouths, and doubtless occasionally by minute portions of food; the lime salts, from the saliva in which they are held in solution. Some observers have described the existence of minute crustacea in salivary calculus, but this is probably an error arising from the appearance presented by the precipitation of lime salts in a colloid fluid."

Tartar (Geo. Watt): "What is it? Well, mainly subphosphate and carbonate of lime (calcium), with an intermixture of epithelial and other organic matter; and as the organic materials undergo the process of putrefaction, offensive gases, more or less held in solution, are also present.

"Why is it deposited in some mouths and not in others? The lime salts named above are probably present in all normal saliva. But when everything else is normal and healthy they are held in solution.

[1] *Dental Medicine.*
[2] *Dental Surgery.*
[3] *Dental Caries.*
[4] *Operative Dentistry.*
[5] *A System of Oral Surgery.*
[6] *Manual of Dental Surgery and Pathology.*

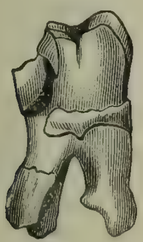
But it is well known that water is the chief constituent of saliva, and that subphosphate and carbonate of lime (calcium) are but slightly if at all soluble in water. But normal saliva is saturated with free carbonic acid, and when thus charged it is able to dissolve and hold these lime (calcium) salts. A part, perhaps the greater portion, of this normal carbonic acid is contained in the saliva as it emerges from the ducts; but if not enough to saturate is present, the residue is readily and promptly taken from the atmosphere.

"If by any process this carbonic acid is taken from the saliva, it cannot hold the salts, and they are precipitated as tartar. Carbonic acid will combine with any ordinary alkaline substance; hence the presence of an alkali in the saliva neutralizes it, and the salts are precipitated as already stated. . . . But the alkali that nearly if not quite always takes this carbonic acid from the saliva is ammonia. It may be a result of the putrefaction of nitrogenous matter within the mouth. . . . To sum up: Normal saliva, though not in itself able to dissolve subphosphate and carbonate of lime (calcium), by the aid of free carbonic acid usually dissolved in it is enabled to dissolve and hold them in complete solution. If from any cause, as expulsion or combination, it is removed from the saliva, these salts are precipitated as tartar. Ordinarily, the carbonic acid is taken into combination with ammonia, abnormally present. To guard against the precipitation of tartar on the teeth, aim to prevent ammoniacal degeneration and the formation of ammonia by the putrefaction of nitrogenous substances within the mouth."

Vaughn (*Chemical Physiology and Pathology*): "Salivary calculi are usually composed of calcium phosphate and carbonate and organic matter."

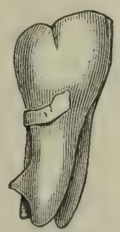
The formation called calcareous which is deposited on the teeth is

FIG. 154.



Deposits on an upper first molar, showing a partial ring at the gum-margin, and deposits on the palatal and mesial buccal roots.[1]

FIG. 155.



View of the same tooth from its palatal aspect.

composed largely of the leptothrix buccalis, and occasionally other micro-organisms are seen in the field when sections are examined microscopically. It is not believed that they assist in or are necessary to the

[1] The accompanying original illustrations (Figs. 154–165 and 167–169) are from specimens in my possession, and were engraved from original drawings made by my friend W. H. Whitslar, M. D., D. D. S., of Youngstown, Ohio.

production of tartar. Many specimens are greasy to the touch and very porous.

Calcareous deposits on the teeth, having their origin in the fluids of the mouth, are called dental tartar or salivary calculus. The concretion invests the crown, or, being deposited around the necks of the teeth and under the free margins of the gums, encircles them (see Figs. 154, 155); but it is never deposited beyond the line of attachment of the pericementum until it has lost its hold on the cementum, when it may form a continuous deposit along the whole length of the tooth and root, covering even the apex, and causing such mechanical irritation as to result in its expulsion. It is stated ordinarily by observers that the most frequent place of deposit on the teeth of dental tartar is on the lingual surfaces of the inferior incisors (see Figs. 156–161) and the buccal surfaces of the superior molars. It is cer-

Fig. 156. Fig. 157. Fig. 158. Fig. 159. Fig. 160. Fig. 161.

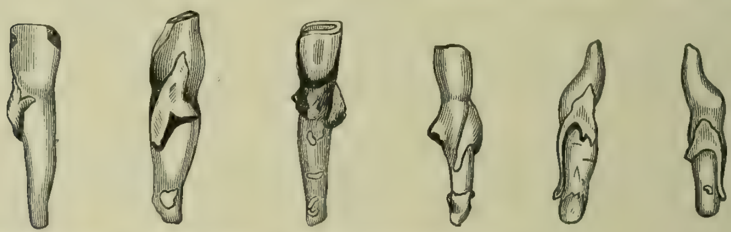


Fig. 156. Inferior Incisor tooth, showing deposits from labial aspect.
Fig. 157. The mesial aspect of the same tooth.
Fig. 158. Lingual view.
Fig. 159–161. Inferior Incisor, showing deposits on the labial and lateral surfaces of a single tooth.

tain that it collects in greater quantity in these localities (see tables of location of deposits), but that in certain regions it is deposited on the palatal surfaces of the superior incisors almost as frequently is a clinical fact which any resident of a locality where nasal catarrh is prevalent knows to be equally true. I have observed it on the lingual surfaces of inferior molars in many cases when there was no deposit on the inferior incisors at all. We find that it collects in buccal cavities, either on the upper or lower teeth, when they are not used for mastication, and also on plates of metal or other bases used for artificial teeth. It may envelop the whole of the crowns of molars when there are no opposing teeth. It collects in rings around the superior central and lateral incisors, cuspids, and even bicuspids. It may be observed on the palatal roots of superior molars when in use; and this variety of salivary concretion is usually firmly adherent to the teeth.

Dental tartar is variously colored, depending somewhat on the habits of the individual, this deposit in the mouth of a smoker being black, but not necessarily hard; the chewer of tobacco, on the contrary, presents varieties both green and black. Deposits in such mouths are very firm in consistence and close-grained. On account of the deposit not being very thick, dense, or large in quantity, it is difficult to make satisfactory specimens for microscopical purposes. The principal varieties are either

whitish-yellow or yellowish-brown in color, very easily crumbling between the fingers or readily fracturing on the application of force or on subjecting it to pressure between flat-nosed pliers or the edge of a cutting instrument. I have seen green tartar and black, soft, white, and yellow in different localities in the same mouth, the latter varieties usually on the buccal surfaces of molars, lingual surfaces of inferior incisors, and occasionally on the labial aspect of the same teeth. Medicines and food may alter the appearance of tartar. White, yellow, light-brown, and dark-brown tartar may be soft when first deposited, but if allowed to remain for a long period it will become very hard, so that it is not true that black tartar is always the hardest and densest variety. The lighter-colored deposits are always more copious than the black varieties except in the mouths of smokers, where the lingual deposit may encrust the whole inner surface of these teeth, so as to make it appear to be a continuous sheet, or it may extend even to the bicuspids. It is generally smooth where exposed to friction of the tongue or cheeks, and presents a nicely-polished aspect, having the appearance of being glazed or resembling a metallic surface. Soft white and yellowish-white deposits are always found in the mouths of pregnant women, and these varieties may be observed in the mouths of persons who habitually use soap as a dentifrice or use a dentifrice which has soap for its chief ingredient. By discontinuing the use of saponaceous dentifrices I have noticed a diminution of these soft deposits on the lingual surfaces of the inferior incisors and elsewhere in the mouth. The daily use of soap and the transverse movement in brushing teeth is not to be commended, as the necks become denuded by the wearing away of the gums, and coincident with this a sensitiveness of the cementum is invariably observed, even where the teeth are of the densest variety. One of the principal arguments presented for the habitual use of soap is that alkalies destroy the function of leptothrix fibres, but no proofs have been furnished.

The deciduous and permanent teeth of the very young (up to the fifteenth year) are pretty generally covered by a green stain which is not calcareous; but it is so frequently seen that a few words concerning its origin may not be considered out of place in an article of this nature. Harris (11th ed.) says: "There is a mucous deposit, to which the teeth of children are especially liable, in the form of a brown or green stain, which has been erroneously called green tartar. This deposit is generally found upon the labial surfaces of the front teeth, more especially upon those of the upper jaw, and varies in color from a light brown to a dark green. From its not collecting upon the posterior teeth and upon the lingual surfaces of the inferior front teeth opposite the mouths of the ducts leading from the salivary glands, there is every reason to conclude that this deposit is not precipitated by the saliva, and hence is altogether different in its origin from salivary calculus. It is generally considered to be a deposit from the mucus when this secretion is in a more acid condition than is natural. From its effects upon the teeth when it is allowed to remain on them for a considerable time, and also from the fact that it is most abundant when the mucus is secreted in large quantities and of a decidedly acid reaction, there is little doubt as to its origin from this secretion."

Wedl[1] says: "The thin deposit, which is distributed without uniformity, cannot be washed off with water nor wiped off, but must be scraped away with a sharp knife, when the enamel will be found bright and intact. Examined with reflected light, the deposit is found to be a granular mass. It is more advantageous to make use of the green deposit, after it has been scraped away, for investigation, or, still better, the membrane of the enamel (Nasmyth's), which may be detached by means of dilute hydrochloric acid: by these means it may readily be demonstrated that the deposit is a green, green-yellowish, uniformly minutely granular mass which is morphologically identical with the matrix of leptothrix. If the membrane of the enamel is preserved in glycerin, the green not unfrequently disappears in a few days, leaving a dirty yellow, yellow-brownish color. I have never observed a penetration of the green, granular mass into the peripheral enamel-layer, though I have met with systems of enamel-prisms containing deposits of pigment which have acquired a greenish color in their cortical layers —a condition which may be explained by the penetration of the green coloring matter."

Tomes[2] says: "In young people the permanent teeth soon after their appearance through the gum may become disfigured by the deposition of dark-green pigment upon the surface of the enamel near its terminal edge. If tartar were present, it would project from the general level of the tooth, but in the cases of green discoloration the surface of the enamel is not raised. As to the nature of this green discoloration, the most diverse views are held. . . . . It is sometimes met with amongst the lower animals, both domesticated and wild, in whom caries is very rarely seen; and the color, which is perhaps of vegetable origin, probably occupies the substance of the enamel cuticle. Some writers have held the opinion that Nasmyth's membrane is a frequent site of incipient caries, and have gone so far as to say that the greenish discoloration often visible around the necks of the teeth in young people was due to the carious disintegration of the cuticula dentis (Ficinus), in which, ultimately, leptothrix may be found. That the cuticula dentis is permeable to fluids is clearly proved by its separation from the enamel when the crown of the tooth is immersed in acid; but its resistant nature renders it very unlikely to be itself the seat of caries. Moreover, this greenish discoloration near the necks of the teeth in young persons often spontaneously disappears, leaving no ill results behind it; and, again, similar discoloration may be found on the teeth of certain wild animals."

"Every one has seen and had occasion to remove the so-called green stain, the 'moss' of the gamin, from human teeth, in both the infant and the adult, the former particularly. This deposit of pigment is said to be on, or rather in, the enamel; and this is true within certain limits. It does affect the inorganic element of enamel, but to a much less extent than is the case with the organic part or matrix, and not at all where the pigment is small in quantity and the stain correspondingly slight in degree. That this is the case may be determined in two ways: First, make a vertical antero-posterior section of a faintly-stained incisor; finish one side perfectly, and cement that side with old balsam to a

[1] *Pathology of the Teeth.* [2] *Dental Surgery.*

glass slide; when the balsam has become hard, grind the opposite side, examining carefully from time to time, until the section has been reduced as nearly as possible to the thickness of an enamel-prism. It will now be found that the greatest deposit of pigment is next the surface, that it grows fainter as we follow the dippings of the matrix into the enamel, and that it is faintest or not to be detected at all in the inorganic portion. Secondly, cement the well-finished central or dentine surface of a cross-section of green-stained enamel to a glass slide in the manner described, and grind, frequently examining it. Note carefully its appearance before grinding, and compare with the appearance of the section when but slightly ground. The result of the first application of the wheel will be the indistinct outlining of the rods, the centres appearing light. These light spots will continue to increase in size as the grinding proceeds until the pigment is narrowed down to the matrix itself. Thus we see that this membrane and its processes in the form of matrix of enamel are the seat of the deposit of pigment, the favorite place, and that its appearance in the inorganic portion is merely incidental."[1]

The views of Magitot, Bell, Garretson, Taft, Coleman, Maury, and others too numerous to mention agree substantially with the above, with the one exception of Magitot, who considers the stain to be a cryptogam. Cases of men and animals are cited to substantiate their respective opinions, some believing that the stain causes caries! I dissent from this latter view entirely. On the deciduous teeth stains are quite often seen; these may generally be rubbed off with pumice or other gritty powder, but the stains on the permanent teeth are very adherent, and nearly always require scraping and vigorous polishing for their removal. Such stains on the teeth, whatever be the color, are not detrimental unless the enamel is defective or roughened from external causes. My opinion is that the green stain is a cryptogam or lichen.

"The structures of these lower plants is at once simple and complex, since we may regard them as formed by the association—or *symbiosis*, as it is technically called—in each lichen of a species of green algæ with a species of colorless fungus of the ascomycetes group" (Trouessart). With reference to the effect on teeth of the retention of such stains no fears need be entertained for their future safety if the enamel is hard and smooth; hence the subject need not be considered here *in extenso*. The labial surfaces of the superior incisors and cuspids in 600 cases were found to present such stains in 94 per cent. of the whole number. After the fifteenth year such stains are of infrequent occurrence.

Removal of Green Stain.—This is easy of accomplishment, when the enamel is unbroken, by the use of finely-levigated pumice, powdered Arkansas stone, flour of emery, or other suitable powder applied in a moist condition, the teeth being vigorously rubbed with wooden or other points fixed in a mandril to be revolved in the dental engine. By making a paste in oil of the powder used the stains will rapidly disappear. When the enamel is roughened or otherwise defective, fine corundum or copper wheels charged with diamond dust or any sub-

[1] J. E. Line, D. D. S., *Dental Cosmos*, September, 1885.

stance which is sufficiently hard to cut are applied; the surfaces will soon become smooth, after which they should be thoroughly polished, and repolished from time to time to ensure freedom from caries. Should the polished surfaces be sensitive to the air or cold liquids, apply the oleo-resin of kava-kava with a wooden point twice or three times every week for two or three weeks, and it will disappear.

Location of Deposits.

Statistics of the location of salivary deposits have never been published, if they have been collected; and, feeling a lively interest in the exact location of these deposits, the author issued a chart, which was extensively circulated, inviting assistance in helping to arrive at definite conclusions. From the returns already received, and from his own records, the undermentioned data are appended. A glance will show that erroneous opinions have heretofore been accepted relating to the supposed abundance and frequency of deposit of dental tartar on the lower incisors. For the purpose of simplifying the task of examining teeth, the tooth was divided in the middle, labial and buccal and palatal and lingual surfaces only being specified, as it was thought that the addition of mesial and distal surfaces would lead to confusion in recording the observations:

	Incisors.			Cuspids.		Bicuspids.		Molars.	
	Upper.	Lower.		Upper.	Lower.	Upper.	Lower.	Upper.	Lower.
Labial	2331	2817	Labial	1427	1643	1917	2016 buccal	2217	1642 buccal
Palatal	1911	3119	Palatal (lingual).	623	1897 (lingual).	1323	1817 lingual	1913	2933 lingual

3763 cases were examined. I was assisted by the following gentlemen: Drs. Geo. H. Cushing, W. F. Litch, E. D. Swain, H. W. Morgan, E. G. Betty, J. G. Reid, J. A. Dunn, Louis Ottofy, A. C. Hewett, L. L. Davis, M. H. Fletcher, J. D. Patterson, Thos. Fillebrown, J. D. and K. C. Moody, C. N. Johnson, M. L. Rhein, P. J. Kester, J. H. Woolley, W. D. Phillips, W. C. Barrett, Thos. L. Gilmer, B. D. Wikoff, and W. W. Walker. Most of the examinations were from private practice, about 200 only being dispensary patients. Many interesting facts were brought out in these examinations not directly bearing on the location of salivary deposits. At some future time an analysis of the whole series of papers will be submitted to the profession.

Composition of Salivary Calculus.

Dental tartar is composed, according to Schehevetskey, of the following matters:

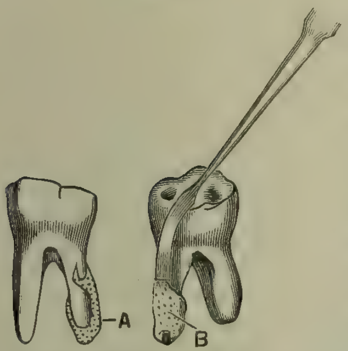
Water and organic matter	22.07
Magnesium phosphate	1.07
Calcium phosphate	67.18
Calcium carbonate	8.13
Calcium fluoride	1.55
	100.00

Dr. Stevenson gives the following:

	Friable soft calculus from molars.	Hard tartar from lower incisors.
Water and organic matter	21.48	17.51
Phosphate of magnesia	1.31	1.31
Phosphate of calcium, with a little carbonate and a trace of fluoride	77.21	81.18
	100.00	100.00

We find a variety of calculus on the roots of teeth which has been called serumal or sanguinary calculus—terms proposed by Dr. G. V. Black and Dr. L. C. Ingersoll to indicate minute deposits on the roots of teeth in phagedenic pericementitis—alveolar ulceration, infectious alveolitis, or pyorrhœa alveolaris, as it is variously termed. These deposits, so far, have not been analyzed. They are found on any surface of the root of a tooth as little islands studding the locality of their deposition and firmly adherent; they are usually dark-colored or light brown, generally presenting a glossy appearance, although at times the surfaces of such deposits may be slightly granular. The deposits are never found coating the surface of a root in sheets, but are easily seen to be little aggregations the size of a small pin's head, always separated from each other. Their origin has not been accurately determined, but they are supposed to be deposited directly from the blood as a result of inflammation of the peridental membrane, which is one of the symptoms of pyorrhœa alveolaris.

Fig. 162.



A, Serumal Calculus covering the side and apex of the root of a lower right first molar (buccal aspect); B, postero-lingual view of the same root, with instrument in position for removing the deposit.

Fig. 163. Fig. 164. Fig. 165.

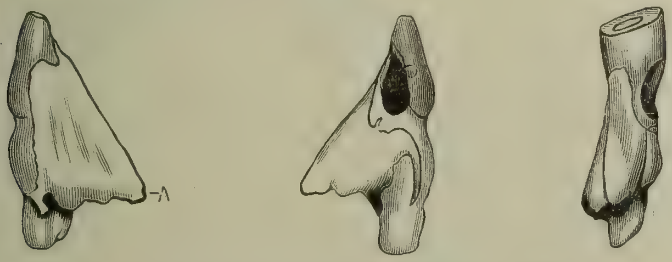
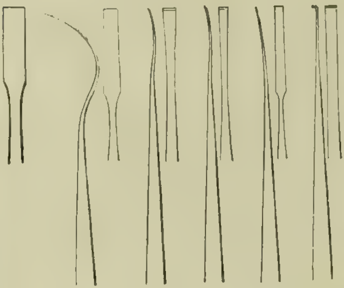


Fig. 163. A, bulky deposit on lower central incisor tooth, proximal view.
Fig. 164. Bulky deposit from mesial surface of same tooth.
Fig. 165. Lingual aspect of the tooth.

These little nodules on the roots of teeth are frequently found near the bottom or sides of pockets or pouches remote from the point of detachment of the gingival margin. I have seen such nodules covering the apices of roots of teeth when they were the subjects of apical peri-

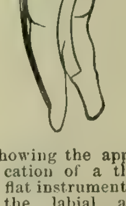
cementitis, It is not the province of this article to further describe these minute deposits, as the section on Phagedenic Pericementitis will furnish a complete history of their origin and formation.[1]

FIG. 166.



It will be conceded that as many teeth are lost from aggregations of salivary deposits as from dental caries. In early youth and up to middle age more teeth are lost by caries, through needless extractions, and neglect to have teeth filled, but after these periods by far the greater number of the remaining teeth disappear as a result of such accumulations. Any one who has had any experience in hospitals and infirmaries will confirm these conclusions. The gums and alveolar processes, and occasionally the cheeks, are inflamed and ulcerated as a result of uncleanliness and neglect, whilst the bulk and extension of the deposits cause a gradual wasting of these tissues and a slow but sure loosening of the teeth. (See Figs. 163–165.) It cannot be denied that the profession in devoting so much attention to methods and materials for filling have well spent their time, yet if a little more energy and thought had been spared for a proper study of hygiene, more teeth could have been saved, and at this late day we might not have to say that we were nearly powerless to save badly-loosened teeth, whether caused by salivary calculus or not. No person can be considered in a state of bodily health when his teeth are covered with tartar. Such teeth may be free from caries, but the breath will be tainted, and a slight ulceration will always be present between the edge of the gum and the deposit. As ordinarily seen in private practice, bulky deposits on the teeth are observed only at rare intervals; hence mouth lesions caused by such deposits are seldom noticed by those practising in large cities with a good clientèle; but the smaller towns and the outskirts of large cities and densely-populated portions where the poor reside are the places to see the ravages for which dental tartar, which is only another name for uncleanliness, is responsible. A day or two spent in a locality where filth is prevalent will convince the most skeptical that tartar is not the innocent agent which it is ordinarily supposed to be. Too great stress cannot be laid on its destructiveness to the gums and alveolar processes. Its presence engenders neglect, and neglect filth,

FIG. 167.

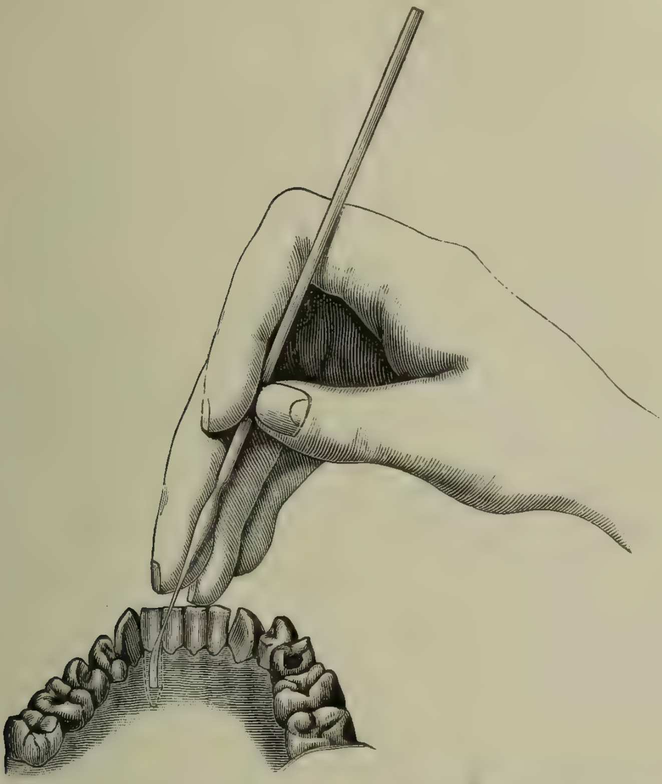


Showing the application of a thin flat instrument to the labial and proximal surfaces of an upper bicuspid (pushing motion).

[1] See Vol. I. p. 968.

and filth loss of the teeth. If dentists themselves will only reflect on the loss of teeth occasioned by *their* neglect to remove such deposits before or after filling a tooth, I think they will be more careful in their future practice. It ought to be understood that no operation preliminary to filling is so important as the removal of tartar—that it must be removed in any event, and always before beginning a series of operations on the teeth. With these few observations we turn to a con-

Fig. 168.



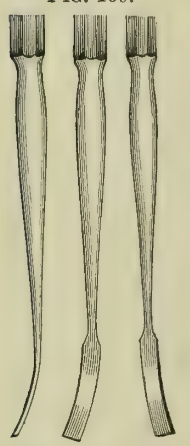
Showing the manner of holding an instrument for detaching calcareous deposits when using the pushing motion. The third finger rests on the edges of the teeth, allowing full freedom of the hand to make rapid and effectual movements in dislodging the calculi.

sideration of the instruments for and the methods of removal of tartar.

Loosening of the teeth is the final result of salivary deposits if they be not removed from time to time. The gums are reddened and become spongy, and bleed very easily when brushed or when touched with an instrument. After a lodgment is once effected, the most careful brushing will fail to detach or wear away the initial deposit; hence the necessity for operative procedure. The instruments requisite for such detachment must be used intelligently and heroically. After the deposit has been detached, unless it be removed from between the

gum and the root it becomes a source of irritation and of subsequent redeposition of a new formation. With minute probes and careful syringing of the mouth with tepid water we may remove the smallest particles. The instruments should in every instance be thoroughly cleansed and disinfected by dipping them into either oxygenated water or a solution of resorcin, v grs. to the ℥j of water. By so doing all possibility of conveying infectious matters into the line beyond the gum-margins is avoided. This is a matter of great importance. Astringent washes for the gums are occasionally indicated after the thorough removal of salivary deposits. Ordinarily, however, cleanliness and careful brushing with properly-shaped brushes are all that is required for after-treatment. Nothing will so effectually cleanse a mouth after the removal of dental tartar as peroxide of hydrogen, and I find, from personal observation, that a solution of resorcin in water the strength of xxx grs. to ℥viij of distilled water, as a wash for two or three days, is very satisfactory. This solution is odorless and almost tasteless, and is not injurious to the mucous membrane. Many excellent formulæ of mouth-washes will be found in the paper on Therapeutics.

FIG. 169.

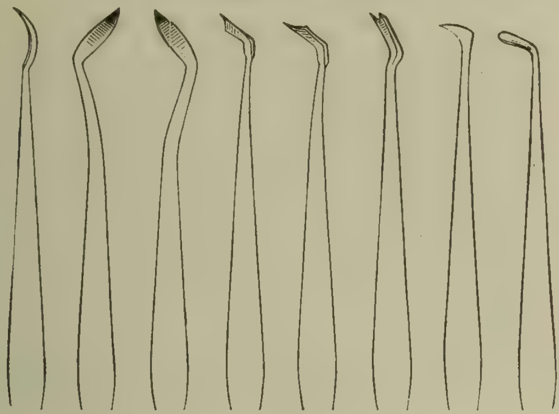


Harlan's right and left scalers for removing deposits from the lingual surfaces of the lower teeth and the proximal surfaces of all teeth, both upper and lower.

The interest which calcareous deposits on the teeth have for dental surgeons is centred, firstly, in preventing their accumulation, and secondly, in effecting a thorough removal of the same. The first proposition implies sound bodily health and habits of cleanliness, which must be insisted upon; and the second, proper instruments for removal and a thorough use of them to accomplish that object. The use of acids and gritty powders for the removal of such deposits is, for two reasons, not recommended by the writer: Acids are deleterious to tooth-structures, and coarse powders are injurious to the soft tissues on account of their easy lodgment between the free margins of the gums and teeth, this furnishing a nidus for subsequent calcareous deposits, as well as causing irritation of the gingival margins, which also favors the deposition of dental tartar. The instruments formerly in use were too clumsy, and most of them necessitated a pulling motion. In recent years these instruments have been superseded by those of smaller calibre for the pulling motion, and thin flat spring-tempered instruments requiring the pushing movement to detach the deposits. (See Fig. 167.) From my own observation and practice, I am convinced that the pushing motion is best adapted in all cases where the concretion does not envelop more than two-thirds of the exposed portion of the tooth. In all other cases chisels and curved instruments with a pulling motion are indicated. The forms presented by Dr. George H. Cushing (Fig. 166), comprising six instruments, are very useful for the removal of all deposits not bulky nor requiring the exercise of great force to detach them. A few trials of such thin, delicately-tempered instruments by one not accustomed to them will convince him of their great utility. While it is undoubtedly true that tartar

may be removed from the teeth with large chisels and scalers, or even with excavators if sufficient time is given to the performance of the

Fig. 170.



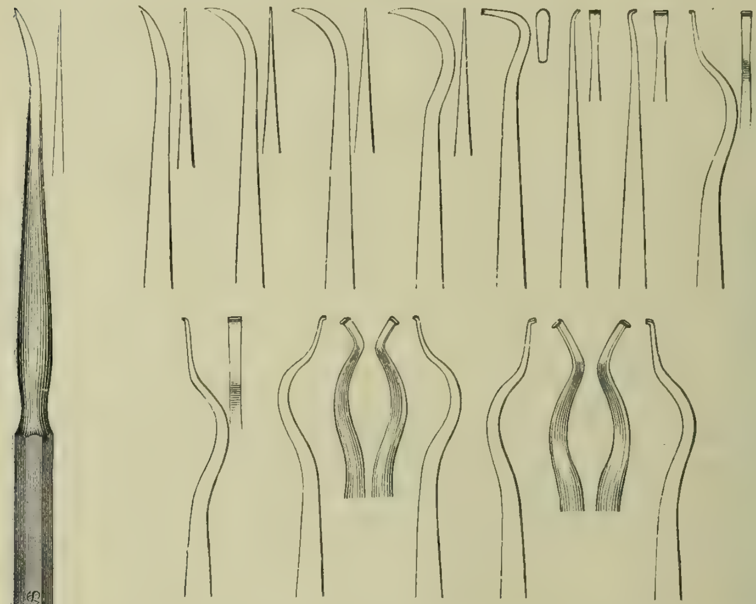
operation, still it is always at the expense of great laceration of the gums, the production of much pain, and the mental determination of the patient to not submit to such a dreadful ordeal in the future. An instrument must be held firmly in the hand to prevent slipping and accidentally wounding the soft parts. (See Fig. 168.) The chin or face should be supported, so that the force applied will accomplish the greatest amount of labor in a given time. Do not be afraid to operate vigorously if the occasion demands it. When the portions of calculus are small, the mouth must be syringed frequently to prevent minute granules from settling between the gums and necks of the teeth.

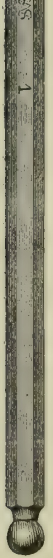
To Dr. Cushing's set I have added two instruments, right and left (see Fig. 169), involving the pushing motion, which are considered equally valuable for removing deposits from the lingual surfaces of the inferior teeth and also from the proximal surfaces of all teeth. Instruments of this character ought not to be nickel-plated if they have octagon handles, as they are not easily held by the fingers. A handle which is file-cut one-half its length toward the blade may be plated without detriment, as the fingers will not slip when the scaler is in use.

Dr. A. O. Rawls (Fig. 170) furnishes a set which are especially useful for the removal of bulky deposits. The instruments devised by Drs. Frank Abbott (Fig. 171), John M. Riggs (Fig. 172), Benjamin Lord (Fig. 173), E. P. Brown (Fig. 174), M. H. Chappell (Fig. 175), H. S. Baylis (Fig. 176), Howe (Fig. 177), and others are well adapted for the removal of salivary concretions on the various surfaces. The dentist who cannot find the proper instrument in the above sets must devise his own favorite scaler. The essential thing to be observed is that each tooth must be operated upon until the whole deposit is removed and ejected from the mouth. I begin the operation by removing the larger concretions first,

and then commence with the third molar below, and completely divest it and the succeeding teeth of the adherent deposit, until every tooth has received its proper cleansing. Many times it requires two or more sittings

Fig. 171.





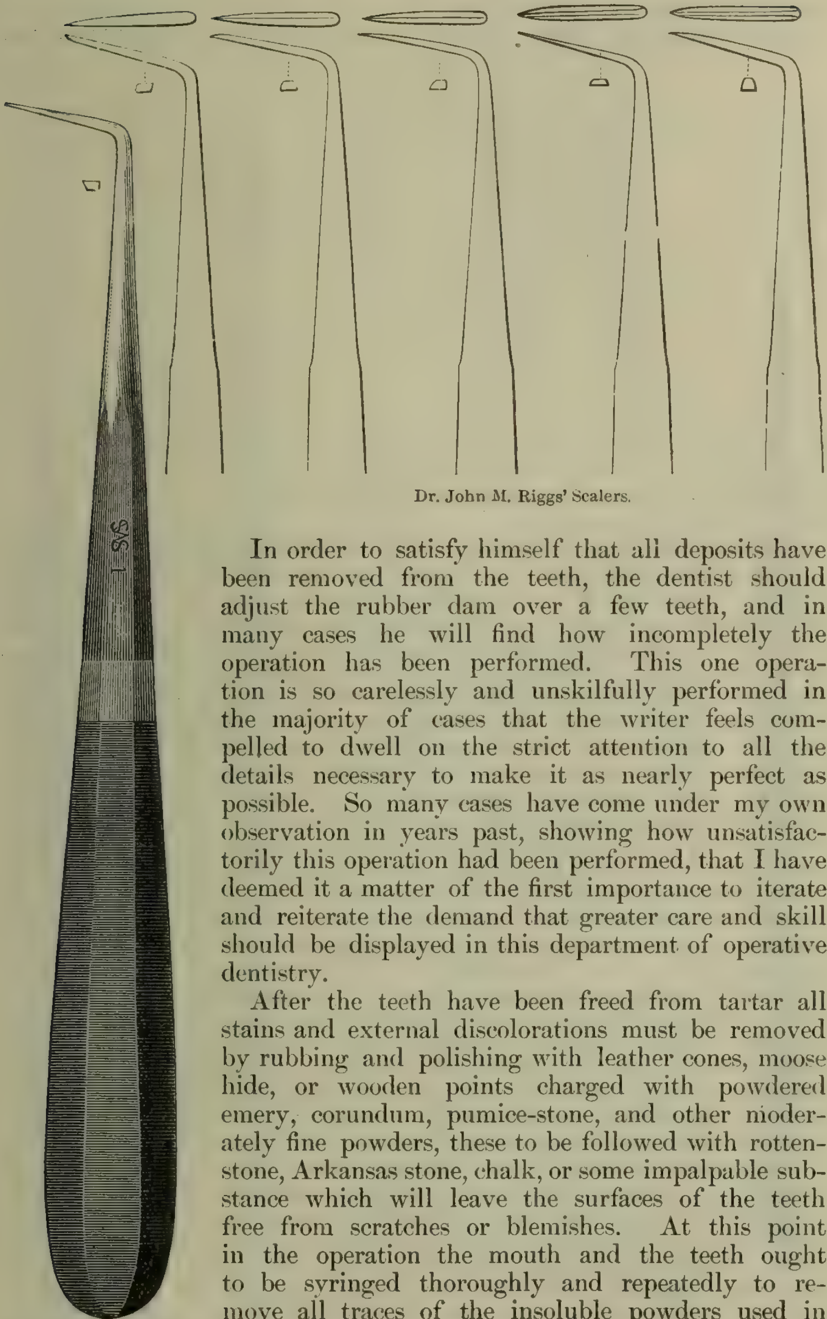
to accomplish this. Two or three days ought to intervene between sittings. Occasionally the rubber dam must be adjusted when the saliva flows freely or the tongue is unruly, in order to properly remove all deposits. No pains should be spared to effect a complete and thorough operation. When the gums are soft and spongy and bleed readily, the operator should use great care in removing the detached portions, as very many cases fail to be benefited by non-attention in thoroughly ridding the mouth of the fragments of calculi.

This is best done by repeatedly syringing the mouth with water slightly warmed. After such a thorough cleansing of the teeth, in most cases the patient will complain when hot or cold fluids come in contact with them, but ordinarily the feeling of sensitiveness will disappear in a few days: should this not be the case, a wash should be prescribed, as follows:

Thymol crystals,	grs. xxx;	
Carbolic-acid crystals,	grs. xxx;	
Glycerin,		
Alcohol, *āā*,	℥iij.	M.

Sig.: To be used on a soft brush, or dilute to suit and use as a mouth-wash

FIG. 172.



Dr. John M. Riggs' Scalers.

In order to satisfy himself that all deposits have been removed from the teeth, the dentist should adjust the rubber dam over a few teeth, and in many cases he will find how incompletely the operation has been performed. This one operation is so carelessly and unskilfully performed in the majority of cases that the writer feels compelled to dwell on the strict attention to all the details necessary to make it as nearly perfect as possible. So many cases have come under my own observation in years past, showing how unsatisfactorily this operation had been performed, that I have deemed it a matter of the first importance to iterate and reiterate the demand that greater care and skill should be displayed in this department of operative dentistry.

After the teeth have been freed from tartar all stains and external discolorations must be removed by rubbing and polishing with leather cones, moose hide, or wooden points charged with powdered emery, corundum, pumice-stone, and other moderately fine powders, these to be followed with rottenstone, Arkansas stone, chalk, or some impalpable substance which will leave the surfaces of the teeth free from scratches or blemishes. At this point in the operation the mouth and the teeth ought to be syringed thoroughly and repeatedly to remove all traces of the insoluble powders used in giving them their final cleansing.

In concluding this brief article the writer deems his whole duty

undone unless a few general remarks are made on the after-attention which the patient's teeth need.

The subject of proper brushing and the use of dentifrices has

FIG. 173.

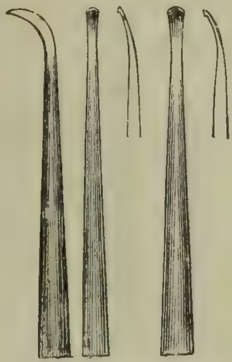

Dr. Benj. Lord's Flat Scalers.

lately begun to attract a share of consideration at the hands of the dentist. In society meetings and occasionally in the journals we read remarks by Dr. X. or Z. on brushing teeth or oral hygiene. Generally, such speeches in a society are seldom listened to or are scarcely heard by the members. Papers on the same subjects are seldom read. All of this is wrong, and does not show progress. The dentist cannot lay too great stress on the proper brushing or cleansing of the teeth. Children especially should be taught by demonstration the use of a brush, floss silk (waxed always), toothpicks, thin strips of rubber, and when and how to use a dentifrice. It may be argued by some that nothing but water should be used for cleansing the mouth: this would be sufficient if the human family lived simply and masticated only solid food, but it does not; hence the necessity for dentifrices. The teeth should be brushed vertically and not transversely; a tooth-powder or paste ought to be used once daily, and then before retiring. The brush should never be dipped in water before using, as moisture is fatal to a proper dislodgment of soft formations on the teeth and of particles of food lodged around or between them. The friction of the gums is tonic and stimulant when a brush is used in this manner. The saliva flows freely, and the mucus as well; both of these secretions are apt to be sluggish and vitiated unless there be proper friction of the gums and mucous membrane in brushing. After a rigorous and thorough rubbing the brush should be washed and allowed to dry, and the mouth be rinsed with water, either tepid or only moderately cold. It is only by following some such method that the teeth can be properly cleansed and kept free from calcareous deposits.

FIG. 174.

E. P. Brown's Crescent Scalers.

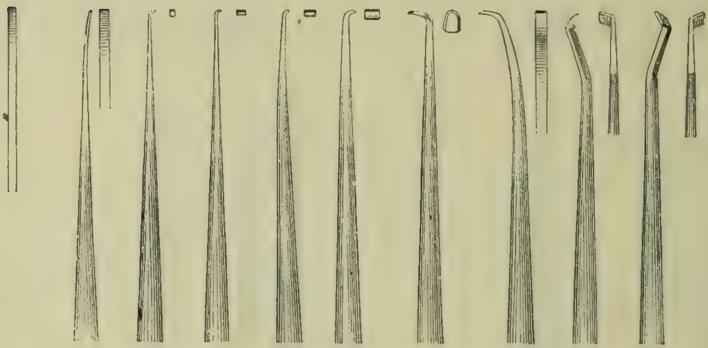
FIG. 175.



M. H. Chappell's Small Scalers.

It will be found that many persons will not follow even the most careful instructions which are given to them concerning the future care of the teeth. Others, on the contrary, will be over-zealous, and by continually and persistently brushing their teeth transversely may wear away the gums and edges of the alveolar process, which would be a calamity. My own opinion is that the teeth do not need to be brushed oftener than twice daily—after breakfast and before retiring for the night. Children, however, should be taught to brush their teeth more frequently, as this daily duty is not likely to be so well performed by the average child between the ages of six and sixteen years. Every practitioner knows that tartar will collect more rapidly on teeth in some mouths than in others. Just why this is true cannot with certainty be determined. The habits, general health of the patient, and the uncertain general hygiene of the whole body must be taken into account in ascertaining the causes of the rapid deposition of dental tartar. When it does collect with great rapidity in spite of careful brushing and the use of dentifrices, it must be removed more frequently, and if possible the cause or causes removed which accelerate its speedy deposition. These causes may be constitutional or local, or both combined It may be necessary to change the diet, order the patient to take outdoor exercise, cease a pernicious habit, or by internal medication correct some constitu-

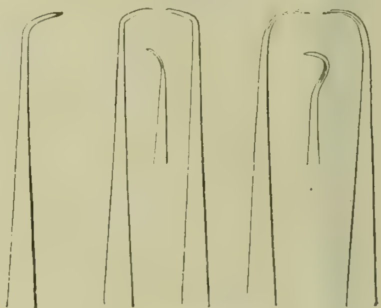
FIG. 176.



Dr. H. S. Baylis's Scalers.

tional condition on which the cause depends. Careful inquiries and close observation for a time may lead to a correct diagnosis. As much attention as this in seeking the causes of the deposition of salivary calculus may seem to some entirely unnecessary, still the importance of preserving the teeth for usefulness in mastication, speech, looks, and comfort must not

FIG. 177.



Dr. Howe's Scalers.

be forgotten in trying to solve this problem. A well-arranged set of teeth, free from caries or tartar, is an anomaly seldom seen, and any amount of care or patience exercised by the dentist in producing such a result is sure to be of benefit to him as well as to the recipient of his skill and knowledge.

DISCOLORED TEETH, AND THEIR TREATMENT.

By JAMES TRUMAN, D. D. S.

Teeth from their position, the use to which they are subjected, the various articles of a perishable nature with which they are surrounded, changes constantly occurring about or on them of a chemical or physiological character, are liable to various degrees of discoloration superficially and internally. Changes of color take place under such varying conditions that, to be satisfactorily studied, they may be arbitrarily divided under the following heads:

1st. Change of color from increase of density.
2d. Change of color on or in enamel.
3d. Change of color from depositions on surface.
4th. Change of color from caries.
5th. Change of color from devitalization.

Increase of Density.—The change of color through increase of density has no pathological significance, but is rather of physiological importance, having a direct bearing on the treatment of disease in other directions, which I have endeavored to make clear in the article on Diseases of the Pulp.[1] In the earlier periods of the development of teeth the basis-substance possesses a minimum amount of lime salts, and it requires a period sometimes covering a lifetime for teeth to reach complete development in this direction. A tooth can never be said to be fully formed from the time in which the outer shell of dentine presents on the pulp to the last hour of its use in the function of mastication in the living animal. This fact, while well known, is not as fully appreciated as it should be in the prognoses made in regard to the future value of teeth. This has been very evident in the past in the extraction of the first permanent molar. It has been sacrificed because of its similarity in density to the deciduous series, the fact being apparently forgotten that the lapse of years would develop a resisting power to destructive forces equal to those teeth developed at a later period.

Depth of color is mainly dependent on density. The varying shades can be described as white, blue, yellow, and their modifications. Temperament and systemic conditions have doubtless much to do with these changes, and are often positive signs of value in the prognosis of disease, and of the character of the force that may be relied upon to combat it. Teeth vary in shade from the cutting edges in incisors and

[1] See Vol. I. p. 888 *et seq.*

canines and the masticating surfaces of bicuspids and molars to the necks. This can only be partially accounted for on the theory that increase of substance gives greater depth of color, and that, consequently, the cervical border, having greater thickness, will present a deeper tint. This shades off to the edges in a lighter tinge of the color of the body, though not unfrequently there will be a combination of tints, as yellow and blue. The various shades of yellow indicate strong, compact teeth and correspondingly vigorous constitutions, while the pearly-blue or white teeth represent the exact opposite. Teeth, therefore, of the latter shades, while beautiful from an artistic sense, are frail and require the constant care of the dentist, and not always with satisfactory results. If preservation be possible until later years, the color changes with increasing density.

Changes in Enamel.—It is not uncommon to find on the enamel spots simulating stains. These are usually of a deeper yellow, and frequently amount to a positive disfigurement of the surface. They are not superficial stains, but are pigmentary deposits in the enamel from a cause not as yet clearly explained. It is not possible to ascribe them to external influences, as the depth of color and circumscribed area forbid such a theory. The explanation will probably be found in arrested nutrition producing mal-development.

Depositions on the Surfaces of Teeth.—These may be produced by a variety of causes. Certain kinds of fruits stain temporarily, as grapes, blackberries, whortleberries, etc. Some medicinal agents will temporarily stain, and many will act on the mineral constituents, but none leave any permanent discoloration unless the enamel has been removed from the surface. Nitrate of silver, when applied to the dentine, as is sometimes thoughtlessly done in the treatment of sensitive dentine, discolors very rapidly. Many other agents under similar conditions will do the same, but as far as my observation goes it is an extremely difficult, if not an impossible, operation to stain enamel from the external surface. The conformation of the enamel-prisms forbids this. If the same vascularity existed in this tissue as in dentine, the normal color of the teeth could not be maintained. The stain produced from any agent at the neck of the tooth is not effected through the enamel, but through the cemental tissue, and from thence rapidly passes into the dentinal tubes. The same result follows from staining in grooves or cavities. Tobacco stains in the same way, teeth being much discolored at certain points by its habitual use, but an abrasion sufficient to reach some part of the dentine must previously have taken place. The dark color of the teeth of the chewer of tobacco is due, undoubtedly, not to the tobacco, but to the constant attrition which, following the general law of slight irritations, produces increased nutrition and very dense structure, and consequently great depth of color.

Color-changes from Caries.—These are not, ordinarily, very extensive or important, as the removal of the carious tissue takes with it nearly all color. It is true that the color of caries spreads to a considerable extent beyond the limit of actual decay, but the area thus affected is not sufficient to produce any serious coloration at points of observation, as the labial surfaces of anterior teeth. The color extends deepest imme-

diately over the pulp, and care must be exercised in excavating not to remove too much of this, as the cutting away will add nothing to the possible preservation from future decay.

Devitalization.—The change of color produced by devitalization of the pulp and its subsequent decomposition is of so marked a character and becomes such a permanent disfigurement that it must be regarded in an entirely different light from any of the preceding.

The remains of the formative tissue which we call the pulp was stated in the article on that organ to be much better understood to-day than at any former period. It can no longer be regarded as a central organ with only possible connections with the main body of the dentine, but is an organ absolutely and intimately connected with the latter, and permeates it in fibres of increasing tenuity throughout the substance. With this view of it, it is not difficult to explain the discoloration following devitalization, and it furnishes the answer to the query, Why does the coloring matter permeate to the extent constantly observed in these teeth? The death of the main central organ means that of the contents of the larger, and necessarily also that of the minute, anastomosing tubes.

Decomposition produces discoloration through a slow disintegration of the organic material and the deposit of carbonaceous matter. It therefore follows that the products producing color are not, necessarily, taken into the tubes by imbibition, though doubtless to a limited extent this is the case, but are produced by local degeneration through putrefactive processes. This change, though very slow in producing results, eventually gives to the tooth the well-known "bluish tinge" of so-called dead teeth or the dirty bluish-yellow of teeth long affected by decomposed matter.

It is unnecessary to enter minutely into the remoter causes of discoloration, as these have been fully described in considering the pulp and its pathological conditions, but they may be summarized as follows:

1st. When death of the tooth is produced by blows, attacks of caries, too rapid pressure in regulating teeth, etc.; the death and devitalization are followed by imbibition of coloring matter through the largest diameter of the tubules; and the already-described local discoloration of the tube-contents in the minuter anastomosing conduits. These changes may occur in teeth affected by caries or without external evidence of disease.

2d. The more aggravated cases, where this color has changed to a bluish-yellow, involving the entire structure of the dentine.

3d. Of the latter class there may be a further subdivision in which these are complicated with periosteal lesions which more or less interfere with efforts at restoration to original color.

Treatment.—The necessity of making some effort to restore the color of teeth changed by devitalization was apparent to dentists very early in the present century. The constant destruction of pulps with the imperfect methods of practice then prevailing necessarily increased this unpleasant complication to such a degree that treatment of the anterior teeth became, as far as appearances were concerned, of

no value whatever. Under the defective modes of treating pulp-canals then prevailing discoloration was certain to follow the filling of teeth. Any attempt to change color is, necessarily, dependent for success upon preliminary measures. Without thoroughness here all subsequent efforts will fail. The early attempts at bleaching before the settled practice of filling root-canals was established was not a success, and it must ever remain a failure unless the minuter structure of dentine be carefully considered.

It has been demonstrated by artificial injection, and still better by sudden congestions of the pulp, that coloring matter may be carried nearly to the final distribution of the minute ramifications of the tubuli. This is an important point, for without this vascularity bleaching would be impossible. With it the possibility exists of extending the whitening process to the peripheral border of the dentine, or, in other words, to its union with the enamel on the crown or cementum in the root.

The diameter of the tubuli is so minute, always decreasing in size until lost in final distribution, that any agent used must require considerable time before it can penetrate to the minute tubes; therefore any attempt to bleach rapidly must, in my judgment, prove a partial failure. The change, if change be made at all, is simply on the walls of the canal, and cannot penetrate to any depth of tissue. If the discoloration is superficial, this mode will be effectual, but not otherwise. So difficult is it to penetrate the tissue in a certain class of teeth with large crowns that I have repeatedly spent several months in vain efforts to change the color of the superior third of the crown. Such cases are rare, and were taken with the view of experiment.

Color can be changed by several of the acids, notably oxalic and nitric. The former destroys the color, and the latter changes dark blue to a yellowish tinge; but as both of these are very destructive, they should never be used except in connection with an antacid. My own experience with the first named, used alone, has been unsatisfactory, although in connection with chlorinated lime others have had excellent results.

Chlorine, free or in some of its combinations, has been the main reliance for bleaching, and that it is the most effectual has been thoroughly demonstrated. Failures have usually been the result of defective manipulation. It has great penetrating power, is a thorough bleacher, it is readily applied, and, in my experience, is harmless.

The possibilities of chlorine were early understood in connection with the bleaching of teeth, but the results were not satisfactory, for the reasons named, and also from the fact that no practical mode had been devised for its use. To present free chlorine to a tooth was an impossibility, owing to its irritating character and, necessarily, superficial action, and no plan had been originated to free it from its compounds. Hence all teeth suitable for bleaching were condemned to remain a perpetual disfigurement. The first attempt to accomplish this was made by myself twenty-five years ago, and the results were published in the *Dental Times* (1864), and in subsequent papers I have endeavored to enforce the value of this operation.

From what has been said in regard to the necessity of securing an agent of sufficient oxidizing power to change discoloration in remote and contracted conduits, it will readily be understood why the first investigations were made with a chlorine compound, and that compound one easily manageable in a cavity of the limited area of the pulp-chamber and canal. The choice fell naturally upon chlorinated lime. The partial success effected by the use of this agent, previously to the date mentioned, was due to the liberation of a limited amount of chlorine in the presence of the weak acids in pulp-canals, but this was too small to be effective. The necessity, therefore, of a higher oxidizing power, which could be accomplished only by a greater quantity of chlorine than was possible by this crude method, led to the employment of an acid in connection with it. As this was well understood and long used in this art, it is rather remarkable that it had never been attempted in bleaching teeth. The fact may probably be attributed to a deep-rooted prejudice against the use of acids in any form in connection with tooth-structure. Whether this is correct or not, no use had been made of this agent in this way up to this time.

Chlorine is liberated from chlorinated lime by all the acids, but not as rapidly by some as by others. It was found that, as rapid action was not desirable, those acids that effected this were not satisfactory. Tartaric acid was one of these. The conclusion arrived at, after much experimenting, was that the best results were attained by the use of a 50-per-cent. solution of acetic acid. Theoretically, this might be regarded as a mistake, but the practical results were of a character to demonstrate the wisdom of the choice, though no assumption is made that it is the best; indeed, later investigations by others would seem to indicate to the contrary.

The difficulty attending the use of chlorinated lime is due to the fact that a good article is rarely to be found. Most of that sold in the shops is absolutely worthless. The failures that have been reported no doubt have occurred from this cause, as well as from defective manipulation. The best plan is to procure it from the manufacturers, and then keep it in closely-stoppered bottles. Good chlorinated lime is in the form of a dry powder. When moist it is worthless. It should have a strong odor of chlorine. A variety of tests are used in chlorometry to ascertain the exact amount of chlorine present in a given quantity of bleaching-powder, but, as exactness is unnecessary for the object aimed at in this treatment, the operator can, if found requisite to test at all, make use of the crude yet sufficiently accurate indigo test. This was one of the earliest methods, and "consisted in preparing a standard solution of sulphate of indigo, which, being of a deep-blue color, was bleached by the chlorine expelled from the lime by the sulphuric acid; and, evidently, the richer the bleaching-powder was in chlorine, the more solution of indigo a certain weight of it could bleach." Roughly, this can be accomplished by adding to a solution of indigo in a test-tube a small quantity of chlorinated lime.; to this add strong acid, the one selected, and note the rapidity of the change of color. If this is very slow or is not accomplished at all, the chlorinated lime should be discarded as unfit for use. The strength of the acid must be deter-

mined by its character. Acetic acid may be used at full strength, but not with the best results. Tartaric acid must be reduced to a comparatively weak solution, as its affinity for lime produces an action entirely too energetic.

Instruments Required.—These, though very simple, require special notice, for neglect in this particular will involve total failure. It must be recognized as a positive essential to success that *no iron or steel instruments must be used in connection with the agent employed.* This is italicized, that it may be impressed on the mind of every operator. The reason for this is that the salts of iron formed discolor the tooth very rapidly. It would be preferable not to use any steel instruments at any stage of the operation, but this is difficult to avoid in the excavation rendered necessary at the earlier periods; but their use may be abandoned in subsequent operations, and a scraper made of hard gold substituted. Instruments may be extemporaneously devised out of hard wood to suit any given case. Ivory, platinum, and gold may be used in place of this, either of the latter materials making efficient tools. The form will depend on the teeth to be treated and the position of the cavity of decay, but the two illustrated will cover all ordinary contingencies, socket-handles being used.

Fig. 178.

The fact that teeth with devitalized pulps, however produced, are always liable to be involved in acute inflammatory conditions must be recognized as an important factor in any treatment attempted. The utmost care must, therefore, be exercised in the preliminary operations to avoid unnecessary irritation. The removal of all remains of decomposed pulp from the canal is of vital importance, but this must not be performed in a rapid, careless manner, as a tooth so circumstanced is extremely sensitive to all external impressions. It is of great moment that no inflammation of the periosteum should supervene, as that necessarily not only complicates the operation, but renders it more doubtful of success. The rule to be remembered is that in proportion to the vitality of the tooth will be the ratio of good results in bleaching.

The removal of the pulp should be followed by the treatment described in the article on the Pulp, and no attempt should be made to change the color until all evidences of putrefaction have been removed, which will be manifested in the absence of the odor of decomposition.

If this preliminary process has been satisfactorily conducted, the next operation may be proceeded with—viz. that of filling the canal at its *upper third.* This should be done with gold, and must be most thoroughly performed. The agent subsequently brought into use is extremely irritating and very penetrating; hence all avenues through which it may reach and act upon the peridental membrane must be effectually closed. The question may be asked, Why fill only the upper third? Because it is absolutely necessary for success that the root shall be bleached as well as the crown. A failure to remember this will possibly result in a rediscoloration from causes to be named hereafter. It must also be remem-

bered that the pulp-chamber in the crown requires the same careful treatment as that given to the canal. It must be thoroughly cleansed of all *débris* to its fullest extent, and that in the incisor and canine teeth is almost to the enamel-line of the cutting edges. Failure in this part of the operation will necessarily result disastrously. I prefer, after cleansing the canal, to follow it with the drill, in order to cut away a portion of the dentine, and also to remove with the excavator or drill a portion of the same tissue in the crown. Having proceeded thus far, the case is prepared for the further process of bleaching.

The next point to be considered is the insertion of the material. Before this is attempted the canals and crown should be well washed with a solution of either borax, sodium bicarbonate, or ammonia to remove fatty matter. It should then be well washed with *distilled water*. The tooth is then invested with the rubber dam and dried. There are several methods of bringing the acid used in connection with the lime. This apparently simple matter is really very difficult. One process is to saturate the entire canal and pulp-chamber with the acid before inserting the chlorinated lime; another is to dip the instrument in the weak acid solution, and then in the lime, and pack rapidly in the cavity; and still another is to make a paste by the use of distilled water and pack this in the tooth, and then apply a stronger acid by means of cotton wrapped round the point used.

There are difficulties attending all these modes, but I have given the preference to the second. The point desired must be kept constantly in view—that of having acid sufficient and of proper strength to break up the compound and set free the chlorine used; secondly, to preserve as much as possible of the latter for bleaching. Before commencing the packing everything should be ready, so that the cavity may be sealed at once. I do not attach much importance to the material used in closing the cavity. Convenience of adaptation must govern the choice. I have used gutta-percha, though objections have been made to this under the supposition that it had a deleterious effect. I have never found any injurious result. Oxyphosphate of zinc or oxychloride of zinc may be used, but either involves greater labor in removal. After sealing the cavity the tooth must be left for a day or two. On the return of the patient remove all the application, avoiding the use of steel instruments. Syringe out the canals with distilled water, and compare the results attained with the sample shade, which as a test of progress should be secured before commencing the bleaching, as it will be found difficult to carry the original dark shade in the mind. If the bleaching has not gone far enough—which will be indicated by the color of the tooth—a second application must be made, and this be repeated until a satisfactory result is obtained. I have not found it necessary to make more than two applications a week. The importance of using distilled water is insisted upon. The reasons for this must be apparent, for in many waters the minerals held in solution, especially those impregnated with iron, will defeat the desired object.

The fear has been frequently expressed that this treatment would tend to make the thin walls of dentine and enamel so frail that fracture would soon follow. I have not noticed any such result; indeed, there

seems to be no effect produced, certainly none of a deleterious character. I have carried the operation through a period of five months in one peculiarly obstinate tooth without observing the slightest change in tissue, and I have treated the merest film of enamel on the labial surface with equally good results.

The immediate bleaching effect will be observed on the lower third of the tooth where the dentine is thinnest. In the majority of cases this will be effected by one application. The greatest difficulty will be found at the gingival border. Here the dentine is very thick, and, as before stated, it will be very slow work, and end in some cases in failure to restore normal color. As this does not, however, materially affect the general appearance, I do not regard it as essential to carry the process to a length of time necessary to effect complete bleaching.

The great objection made to this operation is that the tooth "will rediscolor." My own experience is that when the subsequent operations are properly performed this danger is reduced to a minimum. The fact that dentine is permeated by pulp-prolongations throughout the tissue increases the difficulty of bleaching, and also increases the liability of a return of discoloration. But if the oxidation of the soft contents of the tubes has been properly effected, and then an agent used to fill the canal and act also directly upon this microscopic tissue, there is no reason to fear a return. I am satisfied that this rediscoloration can in most cases be referred to defective manipulation. The operation, simple as it is, requires close attention to details and a clear comprehension of possible results.

The tooth having been restored to a good color, the next consideration is the proper filling to place in it. In this connection the before-mentioned fact still remains an important factor: that the tubuli are still filled with decomposable matter. To allow this to remain without attention to future contingencies must result in eventual failure. To effect any good result, the antiseptic must not only operate in the main canal, but penetrate deeply into the minuter conduits. This quality is possessed in remarkable degree by chloride of zinc, and it maintains the same effect when combined with the oxide of zinc, forming the oxychloride of zinc. If this were universally used as a filling in root-canals, the results would be more satisfactory, but in the canals under consideration its use is imperative. Its power of preserving tissue has been sufficiently noticed in the article on Pulp Diseases. The canal, therefore, and also the pulp-chamber, should be thoroughly filled with this paste. Indeed, I prefer to line the whole of the cavity with it, and then finish with oxyphosphate of zinc. No attempt should be made to fill the crown with gold—not, at least, for several years. If care is taken to pack gutta-percha at the cervical border sufficiently far above the border of the gum to avoid acid action, a filling of oxyphosphate will have all the character of a permanent filling, with the advantage of easy removal if necessity requires it.

The introduction of this process very naturally led others in the same line of experimentation with this and other agents. Dr. Robert Huey of Philadelphia had most satisfactory results from this process, but introduced some changes to increase the rapidity of the action. In a

report of this work he says: "The tooth must be thoroughly cleared of all decayed matter throughout the entire extent of the canal and pulp-chamber. Follow this with a wash of aqua ammonia, as it has been found that any portion of oily matter interferes with the action of the chlorine. Place the rubber dam on the tooth and fill the upper part of the canal contiguous to the foramen. Prepare a solution of oxalic acid after the following formula:

℞. Acidi oxalici, gr. x;
Aquæ destillatæ, ℥j. M.

Have ready the best chlorinated lime that can be procured.

"I commence the bleaching process by dipping one of the gold instruments in the acid solution and again in the lime, and carry this into the tooth as far as possible, continuing until the cavity is full. In the course of five minutes this is removed and the cavity refilled with fresh material, and so continue three or four times in the course of an hour. The largest proportion of cases I have had under treatment have been finished at one sitting. I prefer to use oxalic acid to liberate the chlorine, as the action is more rapid than by either acetic or tartaric, and seems to be more effectual in very difficult cases. If it is necessary to use a temporary stopping after bleaching, I prefer a cement filling to one of gutta-percha. The objection to the latter is that after its use, in some cases, rediscoloration has followed, caused by the admission, I believe, of moisture. The cement filling should not be inserted until after precautions have been taken to dry all the parts of the cavity and canal. For this purpose the hot-air syringe is absolutely essential. Any moisture left is injurious. The cement filling should have a putty-like consistence. When it is necessary to keep the bleaching material in for a longer period than one sitting, gutta-percha must be employed to seal up the cavity."

Dr. E. C. Kirk, in a paper read before the Odontographic Society of Pennsylvania on Oct. 4, 1882, gives "a new method for bleaching discolored teeth." He says: "Having had considerable difficulty in bleaching discolored teeth satisfactorily by means of chlorine, I was led to make some experiments with a view to obtain results which would be permanent. The greatest difficulty in any method, that I am aware of, in which the active bleaching agent is chlorine, is to cause it to act through a considerable body of dentine without repeated applications involving much time and annoyance.

"Chlorine would undoubtedly give satisfactory results if it were possible to keep it in contact with the discolored tissue in sufficient quantity for an adequate length of time; but this object is defeated in all the methods yet devised for its use by two causes: When the pure gas is used or its solution in water, a sufficient quantity cannot be retained in the pulp-chamber and cavity of decay to permeate the walls of the tooth unless they are extremely thin; when the gas is evolved from any of its compounds, such as calcium or sodium hypochlorite, packed in the cavity and moistened with alum solution or dilute acetic or oxalic acid, the decomposition is almost instantaneous, the gas being

eliminated so rapidly that it escapes from the cavity without accomplishing its object, only a small portion acting on the dentine. This necessitates repeated applications, especially if the tooth-walls are of considerable thickness.

"To thoroughly restore a discolored tooth to anything approaching its natural color it is essential that the bleaching agent should permeate the dentinal tubuli as far as their discolored and decomposed contents extend; and this can only be accomplished by evolving the gas slowly and continuously for a considerable length of time within the walls of the tooth. With this idea in view the following method was devised, which, in its present application, so far as I am aware, is original: 100 grains of sodium sulphite, Na_2SO_3, and 70 grains, or, more accurately, 69.841 grains, of boracic acid, HBO_2, both carefully dried, are ground together in a warm, dry mortar to a fine powder. This is to be put into a bottle with an air-tight stopper and kept in a dry place.

"Having adjusted the rubber dam to the tooth to be bleached and the one adjoining it on each side, the cavity of decay is to be cleansed of all *débris*, and the root solidly filled with gold or gutta-percha for half its length. The powder is then to be packed into the remaining portion of the pulp-canal and cavity of decay, leaving just sufficient room to insert a gutta-percha stopping. After the powder has been properly inserted a drop of water is allowed to fall upon it from a pledget of cotton twisted around a broach. Only enough water should be used to moisten the powder or make it thoroughly damp, without washing it out. The cavity of decay is then to be quickly closed with a pellet of gutta-percha (preferably red base-plate) previously prepared of the proper size and warmed. The patient can then be dismissed until the next sitting, when a second application can be made, which usually completes the operation, though when the tooth-walls are very thick and much discolored a third application may be necessary.

"This method is based upon the bleaching power of sulphurous acid. When water is added to the mixture of boracic acid and sodium sulphite, a chemical reaction takes place: the boracic acid unites with the sodium of the sodium sulphite to form sodium borate, at the same time liberating the sulphurous acid which was originally in combination with the sodium, and which is the active bleaching agent. Thus, $Na_2SO_3 + 2HBO_2 = 2NaBO_2 + H_2SO_3$. . . . . Sulphurous acid as a bleacher seems to be fully equal in activity to chlorine, if not superior to it, so far as discolored dentine is concerned. It has no disintegrating action upon tooth-substance, and its results seem to be permanent; a tooth bleached by this method over a year ago shows no tendency to discoloration. . . . . Sulphurous acid bleaches by an entirely different method from chlorine. I am not aware that it possesses any advantage for tooth-bleaching by reason of this difference, but it is of interest from a chemical point of view; and it is well to note it here, as future research may develop the fact that such difference is of importance. Investigation has shown that chlorine acts as a bleaching agent by reason of its strong affinity for hydrogen. Vegetable and animal

colors, when brought in contact with chlorine in the presence of water, have their color discharged, from the fact that the hydrogen of the water is seized upon by the chlorine, and the oxygen set free oxidizes the color and destroys it, chlorine in this case acting *indirectly* as an oxidizing agent. Sulphurous acid, on the contrary, is a reducing agent by reason of its affinity for oxygen, in combining with which it becomes oxidized to sulphuric acid, H_2SO_4.

"On the chemical character, therefore, of the coloring matter depends the choice between sulphurous acid and chlorine for bleaching purposes. Chlorine should be used when the color is an oxidizable compound or rich in hydrogen, while sulphurous acid would apply more particularly to substances highly oxidized and capable of being reduced. . . . .

"Further investigation may show that better results can be produced by some modification of the ingredients of the bleaching-powder. A change which I have recently made consists in the substitution of boric oxide, B_2O_3, for boric acid in the proportion of sodium sulphite 200 grains, boric oxide 111 grains. Theoretically, this gives a little over 1 per cent. more sulphurous acid gas than the first formula given."

While there is no doubt of the correctness of Dr. Kirk's conclusions regarding the action of sulphurous acid, it is equally true that his objections to the use of chlorine as a bleaching agent are not well founded in practice, however seemingly correct they may be in theory.

Dr. A. W. Harlan in a paper on "Bleaching Pulpless Teeth," read before the section in Oral and Dental Surgery of the American Medical Association, held May, 1884, says: "Most of the methods in general use are faulty, and few are useful in all cases. In order to bleach a pulpless tooth the operator must first fill the root for one-third its length. All decay and fragments of pulp should be removed, but discolored dentine, if hard, need not be cut away. Adjust the rubber dam over the tooth to be operated upon, including those immediately contiguous; the cavity is first repeatedly washed with H_2O_2, then carefully dried by the use of the hot-blast syringe. A small quantity of chloride of alumina is next placed within the cavity and moistened with peroxide of hydrogen, and allowed to remain about five minutes, and then washed out with a clear solution of sodæ biboras, $NO_2B_4O_7$—$10H_2O$, and thoroughly dried. The tooth in most cases will be found to have resumed its normal color. The change of color has been brought about by the complete oxidization and destruction of the contents of the tubules. A tooth to be bleached should not be soaked with creasote, carbolic acid, alcohol, or any other substance capable of coagulating albumen. When such agents have been used, first wash the cavity with a clear solution of sodæ biboras, and then follow the method already mentioned.

"The bleaching of the tooth is brought about by the rapid liberation of chlorine from Al_2Cl_6 in the presence of H_2O_2, resulting in the formation of HCl and H_2O, leaving unsatisfied OH and Cl.

"In order to maintain the color, oxychloride of zinc should be used to fill the remainder of the pulp-canal and as much of the cavity of decay as the judgment of the operator will suggest."

Dr. H. C. Register recommends the use of compressed warm air in bleaching teeth. He says: "In bleaching discolored teeth the greatest cause of failure, I apprehend, has been the presence of moisture in the dentine, preventing the absorption of the bleaching agent, and which the mere drying out by absorbents, or even with the ordinary hot-air syringe, does not affect. By gently forcing into the cavity an uninterrupted stream of warm air under pressure, it reaches the terminal ends of the tubuli in both crown and root. If the bleaching agent is then introduced, it will permeate the organ throughout its extent. I have seen discolored teeth of many years' standing thus restored to within a few shades of their healthy neighbors in less than thirty minutes." Since this was written the use of other agents has been abandoned by this gentleman, and the bleaching produced by hot air alone. The writer examined two teeth bleached by this process, the color of which was very satisfactory.

The bleaching of teeth has, from the first introduction of a positive method, been met with remarkable indifference, and at times positive prejudice. Why this should be will remain a problem. The teeth that require this belong to a class condemned for all purposes except that of mastication. The process is generally only applicable to the six anterior teeth, while possibly an occasional bicuspid may be treated with advantage. When these anterior teeth, especially the incisors, are discolored, they are such a positive disfigurement that the operator has only the choice of evils—to bleach, or to excise them and insert an artificial crown. It would seem no difficult matter to come to a decision, or at least to determine to give the natural tooth a chance for future usefulness. The fear of rediscoloration should not weigh in the balance, nor should the possible annoying labor be taken into consideration. All operators are liable to meet with sudden discolorations in the regulating of teeth by the strangulation of the pulp at the apical foramen. When this occurs it is one of the most humiliating of accidents, as it is one of the most annoying to patients. A case that illustrates this is instructive: A prominent operator and professor in one of our colleges met with just such an accident in regulating a central incisor for a young lady. He had never succeeded in bleaching, and, although prejudiced against it, called on me for advice in the difficulty. He was hopeless of results, but attempted again, and this time with entire success. I had the pleasure of seeing this tooth one year subsequent to the operation, and no change was then visible, and the very slight difference in color from the adjoining incisor was scarcely noticeable.

It is probable that not one of the plans suggested is free from faults, but all are without question satisfactory when properly conducted, and all of them will prove failures in the hands of careless, indifferent, and incompetent operators.

ORTHODONTIA.

By S. H. GUILFORD, A. M., D. D. S.

THE teeth of man when in their normal position are arrayed in symmetrical order side by side, their outline as a whole describing very nearly a parabola or semi-ellipse, their variation from these geometrical figures consisting principally in a slight flattening in the region of the incisor teeth, and a tendency to angularity in the region of the cuspids, owing to the marked prominence of these teeth.

While this arrangement is generally regarded as normal and most in harmony with agreeable expression, it is nevertheless slightly variable in regard to the various national types, some having the outlines of the curve more flattened and angular, while others approach more nearly to the true parabolic curve.

Whatever the national type, however, in respect to outline, the teeth, to be normally situated, must occupy their respective and regular position in this line. Any deviation from this constitutes what is known in dental science as an irregularity.

Dental irregularities are usually of two general kinds: one, where certain individual teeth (one or many) stand out of line or are improperly placed in line, but where those still in place describe the normal outline of the particular jaw; the other, where the teeth all stand in line, but where their outline is so changed from a normal standard as to constitute a deformity or malformation. Either of these or a combination of the two is what generally calls for the interference of the dental practitioner.

Irregularities, as to their origin, may be either *hereditary* or *acquired*, the one resulting from causes operating before the birth of the individual or the eruption of teeth, and the other from circumstances attending their eruption or subsequent to it.

The exact causes operating to bring about either of these kinds of irregularity are not as yet perfectly understood, but they are explainable to some degree by certain facts that are known or by hypotheses that are very plausible. For instance, in respect to the hereditary feature we know the tendency on the part of Nature to reproduce herself, and we see the offspring resembling the parent in its dental organism just as it does in form, feature, voice, and gait; or it may inherit some peculiarities from one parent and some from the other, thus embodying in itself the individualities of both. This being the case, if the parents be of different nationalities or very different in size and feature, the one having large teeth and large jaws and the other small teeth and small

jaws, it is very presumable that the child may inherit the small jaw of the one and the large teeth of the other, the disparity between the two resulting in a crowding or malposition of the teeth from insufficient room to accommodate them. This, while not positively proven, is now very generally believed to be a most fruitful source of the irregularities existing in this country, where the intermingling of races is so common.

The acquired form of irregularity we know to be partly due to the too early extraction or too long retention of the deciduous teeth; to accident; to improper habits, such as thumb- or lip-sucking; to tardy eruption of certain teeth, etc.; while in regard to one form of dental irregularity known as the contracted or V-shaped maxilla, we have the hypothesis of Mr. Tomes, attributing it to enlarged tonsils, which, partly closing up the fauces, compel the patient to breathe with the mouth open, thus causing the greatly contracted muscles of the cheek to press unduly upon the buccal teeth, forcing them inward and narrowing the arch. To account for many cases of irregularity we also have the theory of Dr. Kingsley, associating them with derangement or enervation of the trigeminus nerve, brought on by the artificial method of life in vogue to-day among the higher classes of society.

Whatever their origin, however, when they call for interference at all the line of treatment is governed by the same general principles.

The evils attending an irregular or crowded condition of the dental organs are many and great, and should not be lost sight of, either by the practitioner or patient. Among the more prominent of these may be mentioned the distortion of the features and marring of the expression; the interference with speech; the superinducement of caries; and the injury to health resulting from inefficient mastication. The first of these, the matter of *appearance*, although not the most important from a physiological standpoint, is the one that most frequently leads the person to consult the dentist in the matter, the other evils being either lost sight of or regarded as of secondary importance. Correct facial expression is very important, and so is perfect and distinct enunciation; but the danger of loss of the teeth through uncontrollable caries when their malposition is such as to favor it, and the train of evils resulting from the overtaxing of the stomach when mastication cannot be properly performed, should be far greater incentives to the undertaking of any operation for the correction of irregularity.

Whether the deviations from a normal standard, both in regard to the shape of the arch and the arrangement of the teeth in line, are more frequent now than formerly is an unsettled question in the minds of many; but certain it is that the subject of the correction of such deformities is steadily growing in importance and attracting an amount of attention that was formerly unknown. In the early days of the dental profession but little attention was given to this subject, both from its then seeming unimportance and from the great difficulties that attended its accomplishment, owing to the crude character and limited number of appliances then at command for dealing with it.

To-day, however, with the better knowledge of the character of the lesion and the multiplication and perfection of appliances, added to a greater facility of adapting the means to the end, the correction of irreg-

ularities has been greatly simplified, and with the means now at our command we are not only able to bring about almost any desired change in the dental organism, but also to prognosticate our success with comparative certainty.

Closely related, however, to the possibility of accomplishment is the advisability of it under certain circumstances; and in the determining of this our action will necessarily have to be governed by certain attending conditions.

Prominent among these are the age, sex, condition of life, health, family type, etc. of the patient. What might be the proper course to pursue under certain circumstances might be the improper one under other circumstances, and what might be advisable or expedient in one case might be totally inexpedient in another.

Thus, in considering the question of the age at which the correction of an irregularity should be undertaken we have to be governed largely by the character of the operation required. An operation might be undertaken very early in life of so extensive a character as to very severely tax the vital powers at a time when there is no life-force to spare, and where the results, if attained, would be hard if not impossible to retain. The same operation, delayed until a later period, when health and strength are better established, might not only be more easily accomplished, but attended with better results.

So, too, an operation delayed too long may become associated with complications and difficulties that would have been avoided had it been undertaken earlier, when the treatment, in the nature of the case, would have had the element of prevention linked with it.

The correction of irregularity can usually be begun and accomplished at any time between the eruption of the teeth and late in life, but the judgment of the operator will have to be exercised to determine at just what period of life it would be best to undertake it.

Should the surrounding conditions favor it, the earlier the correction is undertaken the better it will be in most cases. The bony tissues of the socket are then in their most pliable condition, making the labor easier and the time shorter; and the foramina for the entrance of the nutrient vessels being then quite large, there will be less liability to trouble from strangulation of the pulp and its consequent devitalization. The old rule that once prevailed of not beginning to correct an irregularity until all the permanent teeth were in place, for fear that the later arrivals by their crowding or pressure would disarrange those that had been brought into place, is now, we think, generally considered obsolete. True, such things may happen and have happened, but it is equally true that such a result may easily be prevented by the exercise of judicious care and watchfulness.

Many years of attention to this subject, aided by a large experience, have firmly convinced the writer that wisdom and prudence alike dictate early interference in cases of irregularity. By this we would not be understood to mean meddlesome interference, for certainly such a thing is possible.

There is a law of Nature tending strongly to harmony, and when accident or unusual circumstances bring about an irregularity in the

dental arch, Nature will do all in her power to combat the opposing influences and bring about harmony. To enable her to do this it is necessary that she have time to accomplish it, and occasionally a little assistance from the dentist. Judicious interference is right and proper, but meddlesome interference will often only accomplish that which a little later Nature would have accomplished unaided.

For instance, during the eruption of the permanent incisors, both superior and inferior (especially the latter), there often appears a slight irregularity. In most cases Nature by her strong inherent powers will correct this condition if time be allowed her; and it is certainly better, in every respect, to allow her to do so than for us to unwisely interfere in the matter.

So, too, a tooth is very often forced out of position or kept out by another tooth of less importance partly occupying its place. Nature alone cannot correct this condition of affairs, but if we aid her by removing the obstructing tooth she will in most cases, unaided (if the patient be young), bring the malposed tooth into line.

Sex, too, is an element to be taken into account in connection with this subject. It does not merit consideration in connection with the advisability and need of an operation—for if the results of neglected irregularity are harmful in respect to one sex, they are certainly equally so in regard to the other—but it is worthy of consideration in regard to the necessity for interference.

Correct facial expression and harmony of feature are far more important to the female than to the male; for, being endowed by Nature with greater beauty of form and feature than man, its absence in any part is more noticeable than it would be in the sterner sex. Besides this, after early youth is passed man has, in the hairy covering of the lip, a means of concealing any deformity in the dental arch, while woman is entirely without this advantage. For these reasons the correction of any irregularity seems more imperative in woman than in man.

The condition in life or social status of the individual, his or her intelligence and power of appreciation, and ability or willingness to properly compensate us for our labor must not be lost sight of in determining whether or how to operate.

A professional man is supposed to labor from motives of beneficence, but he needs, and must have with it, a proper appreciation of his efforts and a compensating reward as incentives to the putting forth of his best endeavors.

There are those whose want of intelligence or lack of culture would lead them to regard with apparent indifference any irregularity on the part of their teeth, or who, if they were benefited by our efforts for correction, would fail to appreciate the benefit conferred. For such it would manifestly not be wise for us to urge any difficult or extended operation, even though they might be able to compensate us liberally for our labor.

So, too, we must not lose sight of the feature of pecuniary reward. Thanks and appreciation are good in their place, and may and should lead us occasionally to serve those who cannot reward us in any other way; but, as a rule, we should not only be paid, but well paid, for

undertaking and successfully carrying out any operation that involves so much labor and calls for the display of so much skill and ingenuity as the correction of irregularities.

The health of the patient also at the time of any proposed operation should be very carefully considered. All dental operations are apt to be taxing to the vital and nervous forces of the patient, but the correction of irregularities, involving often the infliction of considerable pain and much discomfort, in connection with the protracted and annoying character of many operations, seems to be particularly so. Not only this, but the majority of patients presenting for treatment of this nature do so in early youth, during their school-days, when their bodies are in the most critical period of growth, and when, their mental forces being taxed to the utmost and their physical culture possibly neglected, their nervous system is unduly exalted. At such time, unless they possess vital powers of the strongest character, any extended operation upon their teeth may cause them to break down entirely, and infinitely more harm than good result. In cases of children with very weak nervous or vital powers it were better to defer any considerable operation for correction until a later period, or not attempt it at all, for injured health can never be compensated for by benefit conferred upon the dental organs.

With, however, health, condition of life, sex, and age all favoring, the correction of irregularities is attended by many difficulties, in the attempted surmounting of which we are oftentimes doomed to temporary or permanent failure.

Some of these are physiological and mechanical, while others are personal. The former are caused by the peculiarity of the organs operated upon, the latter by the difficulty of entirely controlling the actions of the patient.

The surgery of the mouth, in the very nature of the case, is associated with many difficulties not met with in operating upon other portions of the human frame. Could we, like the general surgeon, perform our work heroically and at once by laying open the part, removing such tissue as we wish displaced, move the organs into the desired positions, fasten them there and bind up the part to give it rest and await the favorable action of Nature's recuperation, our labor would be greatly lessened. Such favorable conditions, however, are not vouchsafed us.

Operations for the correction of irregularity must be slow and gradual in their character: instead of removing tissue that stands in our way, we must depend upon Nature to remove it by her slow method of absorption under the stimulus of pressure; the individual organs whose position we desire to alter are deeply and solidly implanted in a strong bony structure, and, aside from the mechanical difficulty of moving them, we must exercise the greatest care, for they are tender organs, and sudden violence offered them may easily result in their devitalization and possible loss; the pressure exerted to bring about the change we desire must be positive in its character, and continuous as well, and the appliances employed must not only be strong, but neat in their character and occupy little space, so as not to interfere with neighboring organs. More than this, they must meet the hygienic conditions of the

cavity in which they are placed by being made of such substances as shall not exert a deleterious influence upon the oral fluids and the stomach, nor yet rest unduly upon or irritate the soft tissues surrounding them, and thus bring on a morbid condition.

Again, what change we effect must be produced by the direct and powerful pressure of the appliances upon organs that are rounded in outline, smooth of surface, and constantly covered by a lubricating fluid, making it most difficult to obtain a fixed point of resistance on their surfaces, without which our efforts would be fruitless.

After overcoming these difficulties we are met with other and possibly greater ones in the fact that our efforts to retain the apparatus *in situ* and have it do its work efficiently will be constantly antagonized by muscular organs, the lips without and the tongue within, both unavoidably tending toward the displacement of the appliance. This would be bad enough in speech, but it is aggravated in the act of mastication, when we have food, hard in character at times, in the act of being crushed between the teeth and brought forcibly in contact and endangering the fixedness of the appliance.

Not only do we labor under the disadvantage of not being able to give our parts repose while being operated upon, but after our object is attained and the deformity corrected, and when it is so essential that the organs moved should have rest while being retained in their new position until Nature is able to fix them,—even then we are handicapped by the fact that mastication must go on, the organs must be subjected to use, and recuperation will have to take place, if at all, in spite of it.

These constitute the physiological or mechanical difficulties that confront us, but they are not all that we have to contend with. There still remain what we might call personal difficulties arising from the dispositions of our patients or their guardians. Unfortunately for us, we do not have entire control of our patients during the progress of the case. The nature of the treatment is such as to require our seeing them only at certain times. During the intervals they are beyond our control, for we cannot, as we should like, place them under the vigilant eye of a trained nurse or attendant to see that our instructions are carried out and our efforts seconded. When out of our sight, if the appliance should hurt them, as it frequently will during the earlier stages of the case, or be uncomfortable, there is nothing but their moral sense (too often insufficient) to prevent them from removing the fixture and thus greatly retarding our progress. Or, fearful of being hurt on the occasion of a visit, they will often break their appointment and not present themselves until the appliance has performed more than it was intended to, and thus seriously complicate matters.

Mòre annoying, however, than either of these difficulties is the one where, after all the time and labor spent in bringing about a desirable results and the adjustment of the retaining fixture, the patient fails to wear it according to instructions. The teeth in consequence revert to their old positions, allowing failure to overtake success and filling us with regret and mortification.

In bringing malposed teeth into their proper places, certain movements must take place and proper forces be applied to bring about these

movements. The movements generally required are either outward, inward, forward, backward, rotary, or general expansion, sometimes a combination of two or more of them being required. To cause these movements we must bring to bear forces sufficient to accomplish them; and this we do through the medium of such mechanical appliances as seem best to serve our purpose.

According to well-known physical laws, *the greatest good can be obtained from any force only when it is exerted in a direct line with the movement desired.* To this end, in the selection or application of any structures for the moving of teeth we should, where possible, use those that are the most direct in their action. To do this in all cases, however desirable, would be impossible, owing to the position the power-producing instrument would have to occupy, and the consequent interference it would cause (as in the lower jaw) in the motion of the surrounding organs. On this account we very frequently have to consent to such an arrangement of appliance as will give us our force in a line that is not direct, but still effective.

The force applied must be sufficient, but it should not be more than sufficient nor too abruptly applied. The application of a force insufficient to accomplish the desired object would not only prove a failure, but would also involve a serious wasting of the time of both patient and operator; while if it were more than sufficient it might bring about a fracture of one of the alveolar plates, a rupture of a blood-vessel at the apical foramen, or a constriction of nerve-fibre at the same point that would result in the devitalization of the tooth operated upon.

So also in the widening of the arch: if the force be too great or too suddenly applied it may result in the separation of the superior maxillary bones along the palatal suture. The greatest prudence and caution are necessary in the application of force to the teeth.

The point of resistance and the point of delivery of the force must be fixed points.—This is of absolute importance, for without it two evils are likely to result. On the one hand, the power of our force will be partly if not entirely lost, and we will seem to be making progress when we are not; or the shifting of the piece will cause it to bear upon parts not intended to be affected by it, and serious injury result.

A novel and ingenious method of obtaining absolutely fixed points of resistance and delivery in nearly all cases was devised by Dr. W. E. Magill of Erie, Pa., and shown to the writer some twelve years ago. It consists of a band of platinum or gold about a line in width and No. 28 Am. gauge in thickness. This band is made of a size to encircle the tooth to which it is to be applied, and fit it easily but not tightly. After having attached to it pins or hooks or whatever is needed, it is lined with a pasty mixture of phosphate of zinc and slipped over the dry tooth to a point about midway between the cutting edge and the gum. After allowing about five minutes for it to harden, any attachment may be made to it or any proper force applied without danger of its becoming loose. It becomes, to all intents and purposes, a part of the tooth itself, and will remain immovable until, through the completion of the case or for other cause, its removal is desired.

One of these bands attached to the tooth to be operated upon, and

another to the one or more acting as points of resistance, not only assures certainty in our work, but generally obviates the necessity for wearing a plate—often a very great desideratum. The different ways of applying it, and the great advantage to be derived from its employment, will be fully illustrated and made apparent when we come to consider the treatment of specific forms of irregularity.

There are many ways of obtaining reasonably firm points of resistance, all of which will be carefully considered and illustrated in their proper place; but the great superiority of the method just described has been so fully demonstrated in the writer's practice that it has proven more valuable to him than any other simple device he has ever met with.

The resistance at the point from which we exert pressure must be greater than the resistance to be overcome by the pressure.—This fact is so self-evident as to need no demonstration, and yet its importance is so often overlooked or disregarded that it needs to be emphasized. In practice a single tooth is often selected to offer resistance in the moving of another, but this is dangerous unless the tooth selected can be made to compel others adjoining it to assist in the work. A single molar, firmly implanted, may sometimes be sufficient to offer resistance in the moving of a bicuspid or an incisor, but it is always better, if possible, to have that resistance divided among several teeth. A cuspid should never be depended upon to resist alone the pressure needed to move another cuspid. It is as easy and as likely to move the one out of as the other into place. The force of resistance should always be as much distributed as possible for the sake of safety.

Before applying force it should be seen to that there is space sufficient to accommodate the tooth in the new position it is to occupy.—It will readily be seen that this precautionary measure is all-important. Unless there is room to accommodate a tooth, we will either fail in our efforts to move it or succeed only by the expenditure of an amount of force out of all proportion to the requirements of the case. Instead of moving one tooth, we may under such circumstances have to move several at the same time—a difficult and oftentimes unnecessary undertaking. If sufficient room does not exist naturally, we can increase it by separating the adjoining teeth. If the space be so great as not to admit of its being increased by the use of rubber wedges, the object can be accomplished by the use of wood. The writer has been accustomed in such cases to take some soft wood like cottonwood, and, cutting from it a transverse section a little longer than the space to be filled, hammer it in the direction of its length to shorten the fibres, after which it is slightly notched at either end to fit the convexity of the adjoining teeth and fitted into place. The swelling of the piece when it becomes wet will rapidly press the teeth apart.

The method lately advanced by a writer to accomplish this same result by means of a double-ended screw with face-clasps is both unnecessarily complicated and less efficient. Simplicity when combined with efficiency is a great virtue.

In many cases where a tooth is locked out of place the jaw needs or will bear expansion as well. In such cases, of course, we expand the

jaw first, and this will give us room to bring the tooth into position.[1]

Pressure may be either constant or interrupted.—A recent writer upon the subject of irregularities has taken considerable pains to prove that interrupted pressure, according to physiological principles, is the only one suitable to be applied in the moving of teeth. He also argues that a tooth cannot with safety be moved more than a certain distance in a given time. We confess that in a large experience, extending over twenty years, in the treatment of irregularities we have never yet found anything to cause us to believe in either of the above theories. The distance that a tooth can safely be moved in a given time depends so largely upon the kind and character of the tooth and the age and health of the patient that the formulation of a general rule to govern all cases seems to be impossible.

In regard to constant or interrupted pressure, there appears to be no difference in their effect upon the teeth. One seems as good as the other, and we have never seen any ill effects from either when used with discretion. To limit ourselves to one kind only would greatly hamper us in our efforts, and it is the part of wisdom, we think, to use the kind that suits us best or promises the best results. The character of the appliance determined upon will best decide this matter. If it calls for constant pressure, well; if for interrupted, equally well.

Pressure should be exerted as nearly as possible in a line at right angles to the long axis of the tooth.—If exerted at a slight angle from above, no harm will result, as it will only serve to keep the tooth pressed into its socket; but if applied at an angle from below the tooth is liable to be lifted from its socket and complications may ensue.

In selecting the means by which to exert force in the regulating of teeth we have to select from those powers known in physics as "simple machines," such as we can satisfactorily use, as the inclined plane, the wedge, and the screw, and to these add such other direct or indirect means of applying force as can be conveniently used in the mouth. For the production of *direct pressure* we have to depend upon the screw in one of its several forms. It was one of the earliest appliances used for the moving of teeth, but was always made of one of the precious metals until some forty years ago, when Dr. Dwinelle of New York

FIG. 179.

FIG. 180.

Steel Jackscrews.

introduced to the profession the delicate and strong jackscrew made of steel plated with silver or nickel, which has been in use ever since. It is illustrated in Fig. 179. After this the form known as the double

[1] An exception to this rule is sometimes found in the case of a lower incisor placed slightly inside of the arch and held there by the adjoining teeth. In such cases, instead of first making room by spreading apart the adjoining teeth, we have found it easier and more advisable to at once bring pressure to bear upon the locked tooth and allow it to make its own way into place.

Several of the adjoining teeth also will be slightly moved in this act, but that will be the case no matter how the space is gained.

screw was introduced. In this pattern the bar or rod has a thread cut upon each end, one cut to the right and the other to the left, with a movable or revolving crutch attached to each (Fig. 180). With this form we get with the same number of revolutions twice the amount of power that we do from the former or single screw.

Both these forms are generally used for the production of motion known as extension or pressing apart. For the purpose of retraction or drawing together, while 180 may be made to answer, we have another form of the double screw that is usually preferred (Fig. 181). It is preferably made of platinized gold, and consists of a square hollow tube, closed at each end. One end is drilled and tapped to receive a threaded wire, while the other is drilled and accommodates another wire with swivelled head. These wires at their outer extremities are shaped to engage with fixtures applied to the teeth. When jackscrews of the form of either 179 or 180 are used in the mouth, they should never be allowed to rest against the teeth, owing to the harm that is likely to accrue from injury to the enamel or by slipping up against the soft parts. They should be made to rest in or against platinum bands around the teeth, or should operate against portions of a vulcanite plate that are in some measure movable, and thus exert pressure upon the desired tooth or teeth as recommended and illustrated by Dr. Kingsley in his work.

Fig. 181.

Gold Boxscrew.

Simple gold screws, working in a gold box, one of which is attached to either end of a flexible piece of platinized gold extending around two or more teeth and intended to draw them together, have been in use very many years, and served a good purpose; but now that the same end can be attained by the less expensive and simpler method of using rubber ligatures, they have been almost entirely abandoned.

In cases where it is desired to widen the superior arch we have no appliance equal in effectiveness and rapidity of movement to the steel jackscrew, although Mr. Coffin of London has introduced for this movement a combination of steel wire and a split rubber plate that interferes less with the free motion of the tongue, and is sufficiently effective and rapid in its operation for most cases.

For the production of *gradual pressure* we have to depend upon the elasticity of metals or of other substances, mostly vegetable in their character.

Among the metals we are best served by gold that has been alloyed with a small percentage of platinum to give it stiffness and springiness. In former times gold was used that had been beaten to drive the molecules together and thus produce stiffness, but as heating destroyed this property, it could only be used in appliances where great heat was not needed to attach it. Latterly, platinized gold has taken the place of the beaten, because heat does not affect its elasticity. This variety of gold is used in the form of wires and bars, shaped and modelled in an almost innumerable variety of ways to meet the requirements of the work to be performed. Many of the ways in which the writer and others have employed it will be illustrated in the consideration of cases.

Recently, steel wire instead of platinized gold has been used, with the happiest results where soldering is not necessary for its attachment. That it possesses great value cannot be doubted, for with it we can exert a much greater pressure than with platinized gold wire of the same thickness. Its inexpensiveness is also a strong point in its favor.

Among the other substances used for the production of this kind of pressure we may mention hard-rubber plates, compressed wood, sea-tangle tents, silk ligatures, and rings cut from elastic rubber tubing.

Hard-rubber plates are mostly used as means for the attachment of other fixtures or for the protection of the soft parts of the mouth from the pressure of elastic ligatures or other appliances; but they are somewhat elastic in their nature, and by being made to fit so tightly as to require to be sprung into place the effect of their expansion is soon visible on the teeth. When their force is spent they may again be made serviceable in the same direction by warming the plate carefully, slightly flattening it and reintroducing. Their effectiveness is, in the nature of the case, limited, but their utility in many ways is admitted by all.

Compressed wood and sea-tangle tents are usually made serviceable only in connection with hard-rubber plates, they by their elasticity supplying that in which the plate itself is lacking. For their use holes or slots are formed in the vulcanite plate opposite the teeth to be moved, and one or the other of these is introduced dry. Upon being reached by the saliva of the mouth these substances expand and move the teeth next to them a greater or less distance.

Silk ligatures, while at the bottom of the scale in point of contractility, have nevertheless in their day served an important purpose in the moving of teeth, but their action is so limited that to-day they are seldom used, except to hold moved teeth in position for a given time for the purpose of rest or as means of attaching rubber ligatures or other appliances to the teeth.

Elastic ligatures, made by cutting rings from French rubber tubing of different thicknesses and diameters, have been since their introduction, and ever must be, one of our mainstays in the moving of teeth. Their great strength and unequalled resiliency, joined to the numberless ways in which they can be applied and made effective, render them almost indispensable in orthodontic practice. They can be used single or double, and can be wound in and out around and between the teeth, so as to produce not only one motion, but often several contrary ones at the same time.

But while they are thus invaluable to us in the production of desired results, there is also associated with their use an element of great danger. Their powerfulness and incessant action, together with their smooth surface, render them very liable to get out of place or exert their power too strongly or in a wrong direction. For this reason when in position they should be firmly secured, and after that their action closely watched. Seldom should a patient wearing them be allowed to go more than a day or two without being seen.

Another appliance, giving us what we may call, for want of a better term, *variable pressure*, is the inclined plane. Correct in principle, it was in the early days when it was introduced highly regarded for use

in cases where it was applicable. Later on it fell into disuse on account of the difficulty of keeping it in place (especially as the patient would often feel inclined to remove it), and on account of its slowness and seeming clumsiness of action. Latterly, with some modifications in its shape and application, and with better means of keeping it in place, its use has been revived and its merit acknowledged. The modification of it devised by the writer, and its great usefulness in this form, will be fully explained later on.

One of the objections urged against the use of inclined planes has been that during the time of their use the back teeth, not being in contact, would elongate and thus create a new difficulty; but as we never use it for the moving of more than one or two teeth, and can usually accomplish this at the proper age in about ten days' time, we have never found the above-mentioned objection sustained in our practice.

From time to time there have been devised and introduced to the notice of the profession certain methods or systems for the regulating of teeth, by which the authors have claimed to produce satisfactory results in an easy and rapid manner. Many of these have had their day and become obsolete, so that it would be but a waste of time to describe them. There are, however, three systems of recent date that demand our notice.

The first of these was introduced about 1876 by Dr. Farrar, and called by him "the positive system." It is based upon the idea (first developed by him) that when teeth are moved they should always be moved by a force that is positive in character, and not variable; that the only available means of obtaining this kind of force is the screw in some of its different forms; that by its use we can always know with mathematical exactness what amount of force we were applying, and can regulate it to suit the conditions of the case; that by exerting a fixed and definite amount of force in a given time we can keep within physiological bounds; and that the moment we exceed or go beyond this limit we bring about a pathological condition of the parts operated upon.

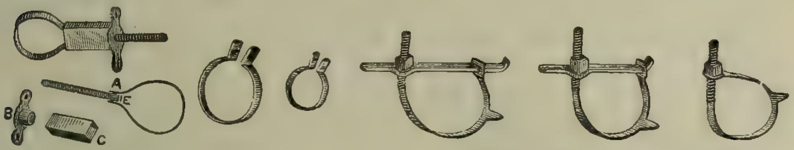
By experiment or by inductive reasoning he has satisfied himself that the limit of movement a tooth can sustain with safety in twenty-four hours is never greater than $\frac{1}{120}$th of an inch—that at this rate a tooth can be moved a quarter of an inch in from forty to sixty days, according to the age of the patient. Another cardinal principle in his method is that the pressure exerted must in all cases be intermittent—that a period of rest must always follow a period of motion.

He claims that by the observance of the above *laws* and the use of the appliances recommended by him teeth can be moved with exactness, with reasonable rapidity, and without pain or inconvenience to the patient.

The appliances are made of 18-karat gold, and two of the principal forms are shown in the annexed cut (Fig. 182). No. 1 is the box wrench with lever, to be attached and drawn up tightly upon a tooth intended to be rotated. A, B, and C are the separate parts of which it is composed. LB and SB are additional band loops for teeth of different sizes. Nos. 2 and 3 are the bar and loop wrenches, with lugs or ears

attached to be bent into the fissures of crowns to prevent the appliance slipping up and irritating the gum. These wrenches are intended as a

Fig. 182.



No. 1. Nos. 2 and 3. No. 4.

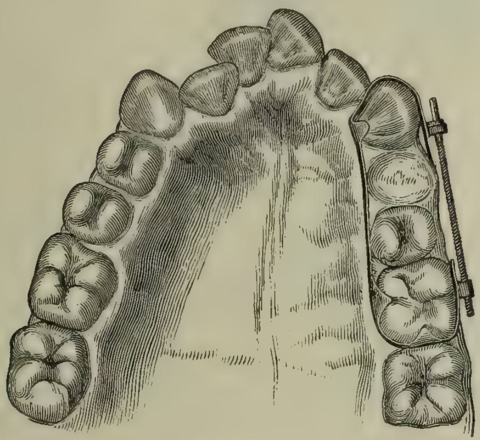
means of securing any further appliance to individual teeth. No. 4 is the rotary loop, used to turn teeth in their sockets.

The simplest form of his appliance for producing traction is shown in Figs. 183 and 184. A more complicated one, showing various fixtures in position for the production of different movements, is well illustrated in Fig. 185.

Fig. 183.

So far as the appliances of this method are concerned, they are certainly, in the main, novel, ingenious, and constructed upon correct mechanical principles. That most of them will do the work they are intended to accomplish admits of no doubt, and yet the method lacks that one essential to mechanical success (especially important in regulating fixtures)—simplicity. Complexity would almost seem to have been aimed at in its devising. To construct such appliances, neat, delicate, and perfect in their workmanship and finish, would tax the powers of the most skilful dental artisan, whilst the carrying forward of the work by the patient would severely try his or her patience and ability. A simpler method, that would accomplish the same results, would certainly be preferred by the great majority of practitioners.

Fig. 184.

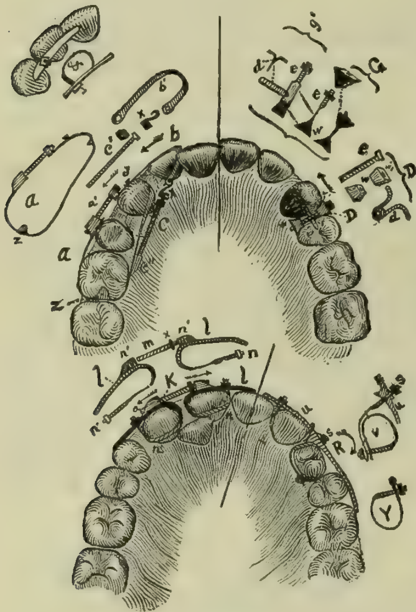


Farrar's Traction Apparatus.

Another objection to the method lies in the fact that by its adoption,

together with the principles upon which it is based, the person using it confines himself to one means of movement, that of the screw. It necessarily excludes the use of rubber ligatures, hard-rubber plates, springs of every form, and a number of other valuable aids that the operator finds most useful. The principles underlying the method are, we fear, not altogether correct. They naturally seem right to the originator, but they have failed to meet the approval and commendation of many who have made the subject under consideration a lifelong study.

Fig. 185.



Farrar's Appliances.

Another method of regulating, designed to meet the requirements of all cases presenting, was brought to the notice of the dental profession in 1882 by Dr. Patrick. Like Dr. Farrar's, it is constructed entirely of gold, but the principle of its action is wholly different. The force exerted in this appliance is derived entirely from the elasticity or springiness of the metal.

The accompanying cut (Fig. 186) and description following will best convey an idea of the appliance and the method of its operation: "It consists of a half-round bar of platinized gold (A, A), curved to correspond with the shape of the arch, having upon it a number of sliding rings, by means of which anchorage is secured and attachment made to the teeth to be moved. The bar is bent with its flat surface inward, and is of sufficient length to allow its ends to rest gently on the buccal surfaces of the first or second molars as desired. The slides are fitted accurately, so as to move steadily. Two of these, which are made longer for the purpose, are used to secure anchorage by soldering to their inner surfaces thin gold bands (B, B) previously fitted to the teeth selected. The bar is held in position by set-screws (C, C) passing through them. Small buttons are soldered to their external surfaces, through which the screws pass to give them greater purchase. To the smaller slides the

Fig. 186.

Patrick Regulator.

different appliances for moving teeth are attached, as wedges, hooks, T-bars, loops, and bands (D, E, F, G, H, I) of various sizes and shapes as required. The mode of operation is very simple. The apparatus acts as a lever, of which the power is the elasticity of the bow-spring, the fulcrums the points used for anchorage, and the resistance the tooth or teeth to be moved. If these are outside the arch, the bow-spring is adjusted so that its flat surface touches all of the projecting teeth, and is firmly set with the set-screws. The wedges are then forced together between the teeth to be moved and the bar; should the wedges cease to act before the teeth are properly placed, the set-screws are loosened, the wedges separated, and the bar taken up until its inner surface is again pressed against the projecting teeth, when it is again set firmly and the wedges brought into play.

"To move teeth outward the elasticity of the bow-spring is made to draw upon them by means of the proper appliance. The appliance can be used on either jaw. Should the bar at any time exhibit a tendency to slip toward the gum, it can be held in its proper place by slipping one of the slides provided with a hook over the cutting edge of a tooth."[1]

The ingenuity displayed in the devising of the appliance is certainly very great, and we regard it as standing first in that class of fixtures made of one material and designed to cover the usual range of cases in practice. In delicacy of construction it somewhat resembles that of Dr. Farrar, but, like it, the different parts of which it is composed, of varying sizes, can now be obtained at the dental dépôts.

One great advantage claimed for it is that in its use no impression or model of the mouth is needed, for the parts, being ready made and at hand, can be placed upon the teeth at once.

The spring principle upon which it acts is a good one, and the readiness with which the piece can be tightened or readjusted without removal from the mouth is a great point in its favor.

With all of its advantages, however—and they certainly are many—it is not without its faults or objectionable features. Every single appliance that aims at a very wide range of action must have some defects. Attachment to a single tooth on either side of the mouth is often not enough to resist great pressure at other points. Attachment to several would give greater security. In most other appliances a tooth attached to has others in front of it to aid in the resistance, because pressure is apt to be on a line with the arch. With the appliance before us, using it, for example, to bring in a cuspid that lies outside of the arch, the fulcrum that was at the point of attachment is transferred to the cuspid, and the tooth used for anchorage is very liable to be sprung out of line by the elasticity of the bar. The writer has had this happen to him in using the fixture, and has had identically the same thing to occur in using Dr. Farrar's appliance with a bow passing in front of the teeth.

When the force needs to be applied in the opposite direction, as the bringing of a cuspid from within outward, all will be well.

The writer has found difficulty also from the tendency of the anchor-bands to shift their position on the teeth. This he remedied by lining

[1] *Dental Cosmos*, vol. xxiv. p. 480, 481.

them with a pasty mixture of phosphate of zinc before slipping them into place.

Another objection to the appliance lies in the fact that it cannot be removed for the cleansing of the teeth; and where any fixture covers so much ground, touching or nearly touching so many teeth, the fluids, being prevented from circulation at such points, will become vitiated and the tooth-structure be liable to suffer in consequence.

The third system of regulating to be described—and differing totally, in manner of construction and operation, from the two preceding ones—is that devised by Mr. Coffin of London. It is not new, having been in use by father and son for some twenty-five years, but it comes as a new thing to us in this country, because it is only within the past few years that we have had any definite knowledge of it. The method appears to have been first publicly brought forward to the world at large through a paper read before the International Medical Congress (held in London, Aug., 1881) by Mr. Walter H. Coffin.

The method has been called by the originator the expansion method, since in nearly all cases he links with the movement of individual teeth a greater or less expansion of the arch. This expansion he considers necessary in nearly all cases to make room in the arch for the malposed tooth.

FIG. 187.

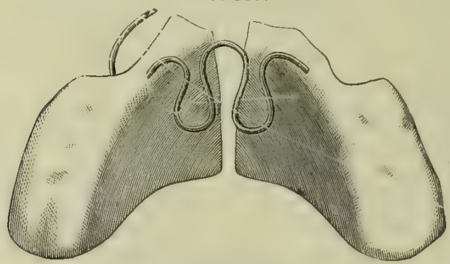
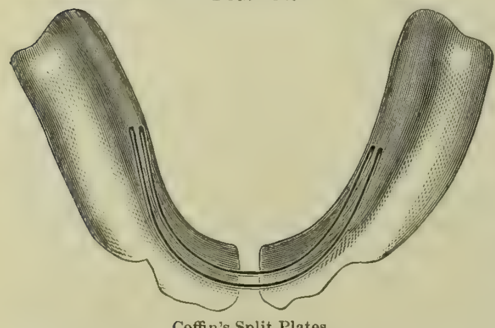


FIG. 188.



Coffin's Split Plates.

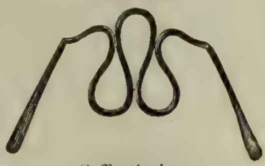
The construction of the appliance and the principle upon which it acts are exceedingly simple. His power is derived from the elasticity of pianoforte wire, while for the attachment of the wire and as points of resistance he uses a vulcanized rubber plate, covering the palate and capping the posterior teeth to give it fixedness in position and ability to resist the strain brought to bear upon it in operating. When it is desired to expand the superior arch, the wire is bent into the following form , lying on top of the plate on its lingual surface with the free ends fastened in the plate.

To produce lateral expansion in the lower jaw the form of the appliance is necessarily different. A simple rubber plate is made in horseshoe form, fitting the gum and lingual surfaces of the teeth and capping the molars. On the lingual face of this plate lie one or two pieces of piano wire suitably curved, with their ends imbedded in the plate. The plate is cut through on the median

line, thus allowing the tension of the wire to be increased from time to time by spreading apart the terminal ends of the plate. Typical forms of an upper and lower plate are represented in Figs. 187 and 188.

The wire used is the ordinary pianoforte wire, to be had of the dealers, and the thickness of the wire Mr. Coffin recommends to be between three and four one-hundredths of an inch for ordinary cases. It should not be annealed, but bent to shape as it comes. Fig. 189 well represents a wire bent to produce expansion of the superior arch.

Fig. 189.



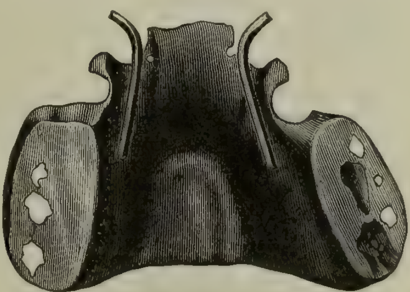
Coffin Spring.

After a model of the mouth is obtained and wax base-plate properly placed upon it to represent the finished vulcanite, the bent wire is laid on top of the wax plate and the free ends of the wire forced into it and properly covered. In filling the second half of the flask the free portion of the wire will be surrounded by plaster, which will securely hold it during the operation of packing and vulcanizing. For convenience, a piece of heavy tin-foil should be laid over the region of the plaster-covered wire, so that the rubber will come out of the flask smooth and polished. After the balance of the plate is polished, it is divided into two parts along the median line by a fine jeweller's saw.

The construction of the lower plate is substantially the same, except that the wires lie against the plate in a continuous smooth curve instead of being corrugated. After being sawn in two, the plate should be introduced without any extension of the wire to produce tension. After being worn for a day or two in this way, to see that no parts of the plate are likely to irritate the soft tissues, the wire is stretched and the pressure begins. This extension of the wire and reintroduction of the plate is continued at intervals of a day or two until the object is accomplished. Mr. Coffin insists upon an accurate impression to begin with, in order that the plate may be a perfect fit at all points. For this purpose he advises the use of gutta-percha, but we have found plaster of Paris or the modelling compound to give most satisfactory results.

Another modification of the plate where expansion of the arch is not desired, but only the movement of a single tooth, consists in making it in the usual way without the zigzag wire along the median line, and not dividing it into parts. A single long piece of wire, bent at right angles near one end and flattened at the other, is imbedded at its flattened end into the plate, while the other end and a long portion besides is free. The end near the right angle rests against the tooth to be moved, and as the latter yields to pressure the wire is bent to follow it up and continue the work. Fig. 190 shows a plate of this construction. Two wires can be inserted to operate upon two teeth at the same time.

Fig. 190.



Coffin Solid Plate.

Where both expansion and the moving of individual teeth are desired at the same time, this latter form of plate is constructed with the  wire along the median line, and the plate is divided on completion.

The originator claims for his method and appliances great simplicity, ease of construction, and inexpensiveness; an almost universal range of application; perfect control of force applied and direct action; comparative painlessness from non-irritation of soft tissues; perfect fixedness and least unsightliness; ease of removal for cleansing; and little interference with speech and mastication. All these claims must, we think, be granted, and in doing so we accord it probably the highest place in the list of dental regulating appliances. In an extended experience with this method of regulating the writer has found its shortcomings to be very few, and these probably surmountable with further experience.

Retaining Appliances.—After malposed teeth have been moved into their proper positions it is all-important that they be held there until they have grown firm. In the act of moving a tooth two physiological processes take place in the surrounding hard tissues. That portion of the alveolar process which lies next to the tooth on the side toward which it is moving is removed by gradual absorption or reconversion into its original elements, while on the opposite side callus is thrown out which is slowly converted into bone. The tendency of teeth after being moved to return to the position from which they have been moved is very great, and if left to themselves they will quickly so return. If, however, they be retained in their new positions until a new osseous deposit has filled up the space created by their change of position, they will ever after remain there. The time required for this new bone to form and become dense varies with the age of the patient, but a less time than six months should never be allowed for it. In persons over thirty it will usually be necessary to retain the moved teeth in their new positions for a year before it is safe to leave off all artificial support.

To hold them in their new position various fixtures are used, known as retaining appliances. They may be made of vulcanized rubber or metal, or of a combination of the two. Where a tooth in one jaw has been held out of its normal position by false occlusion with some tooth in the opposite jaw, it will usually be unnecessary, after it is brought into position, to take any means to keep it there, as the restored normal occlusion will effect this object. But where such is not the case, or where several teeth have been moved or the arch expanded, some form of retaining appliance will have to be worn.

Where teeth have been moved from within the arch outward, or where the arch has been enlarged, the simplest and probably the best form of retaining fixture is a thin rubber plate covering the palatine arch and nicely fitting all the teeth at their necks. It can be made with or without a vacuum-chamber, though the latter is usually to be preferred, since it adds to the firmness of the plate. It can be modified slightly, so as to do additional service in the holding in place of individual teeth that have been moved from an exterior position into line. Illustrations of many modifications of this kind will be found accompanying the description of practical cases subsequently given.

In cases requiring the retaining in place of a number of teeth that had formerly stood outside of the arch, or where some had stood outside and some inside, probably no plan yet devised is so efficient, and at the same time so simple, as the one proposed many years ago by Dr. Richardson. The accompanying illustration (Fig. 191) will show its general appearance. It consists of two narrow strips of vulcanized rubber about one-fourth of an inch in width, the one fitting the gum and necks of teeth on the palatine surface, and the other the same portions on the buccal or labial surface. The two are either continuous around the last molar, or they are separated there and joined at two other points by pieces of flattened gold wire vulcanized into them. These wires can be placed at points where a tooth is missing or where space exists between the teeth, or, if the articulation of the teeth be not too close, they can be passed over the depressions between crowns on the masticating surface. The fixture is light, occupies little space in the mouth, and is not very noticeable.

FIG. 191.

Richardson's Retainer.

While rubber plates of any form are very efficient as retaining appliances, they have one objectionable feature associated with them—that of maintaining contact with so much tooth-structure throughout their extent. By retaining the vitiated secretions and particles of food at so many points they are liable to cause injury. For this reason the writer has for many years avoided making retaining plates of rubber wherever he could do without them. As a substitute for them he was led to devise a number of little appliances of gold and platinum, occupying but very little room in the mouth, and attached firmly to the regulated teeth by one of the zinc cements. Wherever a single tooth (and in many instances where more than one) has been moved from an external or internal position into line, or has been rotated in its socket, these little fixtures can be used as retainers with perfect success and to the exclusion of a more bulky plate.

They possess another valuable feature (where they can be used), to which regard was had in their devising—that of preventing all motion of the regulated tooth during the time that it is becoming fixed in place. The importance of this absence of motion during the formation of new bone-tissue is well illustrated in the necessity for placing a fractured bone in immovable splints.

The removal and replacement of a larger regulating appliance for the purpose of cleansing (always important) necessarily involves a slight motion of the retained teeth. Besides this, a removable fixture is at times liable to be left off by the patient for too long a period, during which time the teeth will move toward their former positions, only to

be brought back when the appliance is reinserted. All such movements, slight though they be, will retard the process of bone formation and consolidation. For these reasons it must appear that a retainer which will hold the tooth firm and which cannot be removed by the patient for any purpose whatsoever possesses obvious superiority.

As before intimated, these small metal appliances have only a limited range of application, but in cases where they can be used the writer has found them invaluable.

Closely related to, and having a most important bearing upon, the treatment of irregularity is the question of extraction either as a preventive or corrective measure.

Where, from any cause, the number and size of the teeth seem to be too great for the space intended to accommodate them, or where the difficulties attending their being brought into position appear to be unusually great, the extraction of one or more of the teeth readily suggests itself to the practitioner as the readiest way out of the difficulty. The operator, however, must guard himself against adopting and carrying out the suggestion too readily, for, while judicious extraction is often one of the most potent and valuable aids in the prevention or correction of irregularities, injudicious extraction is one of the most pernicious and unfortunate practices the operator can resort to.

Extraction where extraction is clearly indicated will not only often simplify a very complicated case, but relieve both patient and practitioner of much wearisome and sometimes painful effort.

On the other hand, extraction where it is not indicated as best for the patient will often not only complicate an otherwise comparatively simple case, but may be followed by a train of ills which no subsequent amount of time, effort, and suffering will entirely remedy.

In view of these facts, it becomes important to consider when and under what circumstances it is best to extract, so that we may not unwisely fall into the error of doing that which both the patient and ourselves will afterward wish had not been done. Probably no question at all associated with the correction of irregularities can lay claim to greater importance than this one of advisability in extracting; and no one will appreciate its importance more fully than he who has time and again, in the course of his practice, committed the error of doing in the matter that which at the time seemed to be best, but which subsequent events proved to have been the worst course to pursue.

A large experience in orthodontia, made rich by the valuable lessons gained from failures, will enable the practitioner to decide easily and with comparative certainty of success *when* and when *not* to extract in the cases presenting in his practice; but to formulate the reasoning by which he arrives at his conclusions and properly convey to others in words his ideas is a difficult, and to a certain extent impossible, task.

So many attending circumstances enter into the consideration of the various cases presenting, such as the character of the irregularity, its position in the mouth, the quality and condition of the teeth, the character of the occlusion, the facial expression, the age, sex, and physical condition, etc., that what would be advisable in one case would be totally inadmissible in another apparently differing but little from the first.

Surrendering, therefore, at the outset, the expectation of making entirely clear or complete all the principles intended to guide those less fully informed upon the subject, there are nevertheless certain general rules that may be laid down for guidance in the prognosis of cases that will be of benefit to the younger practitioner.

The question of extraction as related to irregularity will first arise in reference to the deciduous set, for with their treatment largely lies the possibility of future irregularity or its prevention. It is well understood that these teeth are temporary in their character, and are intended to last only until the arrival of the permanent ones. As these by turn make their way to the surface, their antecedent temporary ones become loose through absorption of their roots, and at the proper time drop out or are picked off to yield the space to their successors. The order and time of their loss and the eruption of their permanent successors may be approximately set down as follows:

Central incisors	at the	age of	7
Lateral	"	"	8
First molar	"	"	9
Second molar	"	"	11
Cuspid	"	"	13

In making their appearance the lower permanent incisors erupt inside of the temporary ones, while in the superior maxilla the same teeth erupt outside of their predecessors.

The permanent teeth, with one exception, are in all cases larger than the temporary ones which they supplant. It therefore happens in the inferior maxilla with four larger incisors to take the place of four smaller ones, and the former erupting inside the arch, that they frequently become crowded and irregular for want of room to accommodate them, and there arises the temptation to extract the deciduous laterals to make more room for the erupting centrals, and later on to extract the deciduous cuspids to prevent the permanent laterals from occupying an abnormal position. To the inexperienced such a course of procedure would probably commend itself, but to one versed in such matters it could not be entertained for a moment.

True, if these new teeth are given plenty of room by extraction their assuming an irregular position will usually be prevented, or if slightly out of line before the extraction took place they will of their own accord generally assume their proper positions, the action of the tongue from within and the lips from without often contributing largely to this result.

So, too, when the bicuspids come to take their place in the arch, there will be plenty of room to accommodate them, from the fact that their joint diameters are less than those of their predecessors.

When, however, a year or two later, the permanent cuspid comes to take its place, it will be found that its normal position has already been occupied by the approximation of the permanent lateral and first bicuspid. Under the circumstances, therefore, it is forced out of line, and when erupted lies outside of and over the two teeth that have monopolized its place. Here, then, we find, when too late to be prevented, that in our efforts to prevent an irregularity among the incisors we have

in reality been creating a greater one close at hand, which will be almost impossible of correction without the sacrifice of a sound tooth. In the end we are confronted with an evil far greater than the one we sought to prevent. Had we left the temporary cuspids in their place until the proper time for their loss had arrived, notwithstanding the crowding of the incisors, we would have preserved room for the permanent cuspids and prevented their irregular position. Not only that, but by the time they were properly in place it would have been found that the incisors had partly corrected their own malposition by the enlargement of the process giving them room and the tongue pressing them into line. These occurrences will take place if Nature follows her usual course; but as she does not always do so, it does happen that at times, in spite of the greatest care and watchfulness and our refusal to extract before the proper time, the lower incisors will erupt out of line and fail to right themselves without extraneous aid.

It may happen also that through the meddlesome interference of the patient himself or of his parents, or, worse still, of an ignorant practitioner, the deciduous teeth have been extracted prematurely, and the harm done before the case is brought to our notice.

Under such circumstances we can only strive to remedy by mechanical means what good judgment would certainly have prevented.

The manner in which aid can best be rendered in such cases will be explained in the consideration of practical cases.

Occasionally, one or more of the permanent lower incisors will show a tendency to erupt outside instead of inside of the temporary ones. In such cases it would be the part of wisdom to remove the deciduous tooth at once, and attempt to abort the irregularity by directing the patient to frequently press the new tooth in the direction of its proper position with the finger or thumb. This condition, however, is an unusual one.

In the superior arch, by virtue of the incisors erupting anteriorly to the temporary ones, and thus occupying the arc of a greater circle, there is not the same tendency to irregular arrangement as in the inferior arch. With all this in their favor, however, we do frequently find them erupting irregularly, and at times giving us much trouble as a consequence. The trouble usually arises, when it occurs, either from the premature extraction or from the injudicious retention of one or more of the temporary teeth when their roots are deflecting the permanent teeth then in course of eruption.

In the upper jaw, as in the lower, when by reason of uncontrollable disease or accident any of the temporary molars are lost before their time, such loss is usually unattended with any tendency to irregularity on the part of the bicuspids, but the premature loss of the superior cuspid is followed by the same ill results as in the lower jaw, and is one of the most fruitful sources of irregularity.

We are therefore justified in concluding that extraction of any of the deciduous incisors before their time in favor of the incoming permanent ones is, in nearly all cases, bad practice, and that, above all, the temporary cuspids should be retained *in situ* until their successors are ready to take their place.

What we have thus far said relates to the extraction or non-extraction

of deciduous teeth as a preventive measure, and presupposes that the patient has been placed under our care very early in life. In many cases, however, we do not see the patient until the permanent teeth are all in place, and the irregularity, if it exists, is already established. In such an event the time for *preventive* measures has largely passed, and we have to concern ourselves with measures that are principally *corrective* in character.

The following rules may be laid down as governing extraction as it pertains to the permanent teeth in the treatment of irregularity :

Always avoid, if possible, extracting any of the six anterior teeth in the superior arch.—We would urge this, because it is nearly always unnecessary to extract them, and because their absence, owing to their prominent position, would be more noticeable than the absence of other teeth in the arch. If the anterior teeth be sound and only irregular in position, the extraction of a bicuspid from one or both sides will usually give us sufficient room for spreading the anterior teeth and moving them into their proper position.

It has happened, however, to the writer and others to meet with cases where the superior laterals were locked inside of the arch by the close approximation of centrals and cuspids, and where the laterals were withal so badly injured by decay and disease as to render their usefulness doubtful if brought into line. In such few cases it was deemed best to extract the laterals, especially as their absence would not be more noticeable afterward than before, and because there was a good occlusion between the rest of the teeth in the mouth.

The writer had two cases in one year present to him for the reduction of prominence in the superior front teeth. In each case there was a broken or badly diseased right central incisor that was past hope of redemption. In these cases it did not happen particularly amiss, for the extraction of the roots afforded room for drawing in the remaining five teeth, thus easily reducing the deformity and at the same time closing the space made by their loss. The appearance of the patient in each instance was greatly improved, and the absence of even so large a tooth as the central was scarcely noticeable. The models of these cases before and after treatment, together with the means and appliances used, will be found fully illustrated in subsequent pages.

In the cases just mentioned it must be borne in mind that advantage was simply taken of an existing condition to simplify an operation. Had the teeth been good, it would have been criminal to extract them.

In another case, a girl eleven years of age had lost a right superior central incisor through a fall from a swing. Two days after the accident, and when the tooth had been mislaid or thrown away, she was brought for treatment. Only two methods of remedying the difficulty suggested themselves. One was the wearing of an artificial tooth ; the other, drawing the teeth together to close the space. The latter plan was decided upon, and successfully carried into effect, but, unfortunately, as there had been no protrusion formerly, and there was contraction afterward, the superior teeth no longer overlapped the lower ones, but met them edge to edge, thus giving the upper jaw a flattened appearance which was in itself a deformity. The patient was saved the

annoyance of wearing an artificial tooth, but her facial expression was injured in consequence.

Such cases as those just alluded to are exceedingly rare, and are only mentioned as extraordinary exceptions to a very good rule. Aside from the centrals, there is probably less excuse for the extraction of the cuspids than any of the anterior teeth, and yet it is, unfortunately, too often resorted to.

If, for any cause, the cuspids erupt abnormally, and there is no room for them in the arch, if it be not advisable to expand the arch the first bicuspids should be extracted to make room for them. The cuspid being the stronger and more durable tooth of the two, it should be given the preference in the struggle for existence. More than this, owing to its long and prominent root it gives a characteristic expression to the face, and if it be lost the expression will be irretrievably lost with it. The first bicuspid proves a very poor substitute for it in every way.

In the lower jaw any one of the incisors may without harm be extracted to gain space.—Slight irregularity or crowding of the inferior incisors is of such common occurrence as to have almost become the rule instead of the exception. Their partial concealment, together with the usual freedom of the condition from ill results, causes any interference to seem meddlesome rather than otherwise, if the irregularity be but trifling. In cases, however, where the crowding is excessive and calls for correction, it is usually the easier and better plan to extract one of the implicated teeth and bring the others together and into line. The four teeth are so nearly alike in size and character that the loss is not usually noticed when one has been removed. It is sometimes perplexing to decide which of the four to extract, but the one most out of line, and in consequence the one that will create the least space by its removal, should usually be selected.

In respect to the loss of the inferior cuspid the same remarks apply as to its fellow in the opposite jaw.

Back of the anterior teeth, if all are equally good and one must be removed, select the one nearest and posterior to the one out of position.—As so large a proportion of the irregularities we are called upon to correct pertain to the anterior teeth, and as it is so advisable to retain these, extraction for room, when necessary, generally falls upon one of the teeth posterior to the cuspids. Which of these it is best to extract to make room for a malposed cuspid or incisor has been a subject of controversy among practitioners for many years.

Some have claimed that as the statistical tables show the first molar to be by far the least permanent of all the permanent teeth, it should generally be selected as the one to be sacrificed. Others, on the contrary, have contended that as the first and second bicuspids are both frail teeth, and are often lost early in life, and as from its greater size the first molar is so much more valuable in mastication, it should be preserved and one of the bicuspids sacrificed.

There is truth in both these arguments, but we feel satisfied that under the conditions named, *all equally good* at the time, wisdom will dictate the removal of the one nearest the point of difficulty, for in so doing we greatly simplify the operation for correction and effect a

saving all around. Simplicity in surgical as well as mechanical matters is a great desideratum. Indeed, it not unfrequently happens that where a cuspid is out of line the first bicuspid assumes its place in the articulation, so that if we were to extract the first molar, both first and second bicuspids would have to be moved out of their position of good occlusion into a space farther back—a feat very difficult, and oftentimes well-nigh impossible, of accomplishment. With the simple extraction of the first bicuspid in such a case the cuspid will usually, without any assistance, fall into its place.

If a tooth other than the one nearest to that in malposition be defective, and not too far distant from point of irregularity, extract it instead.—The second molar, decayed or sound, is usually too far distant to avail by its extraction in giving room in the anterior part of the arch. If the bicuspids be sound and the occlusion does not interfere with their backward movement, the first molar, if very defective, may be extracted in preference to a sound tooth in advance of it.

So, too, if the second bicuspid be carious or defective and the first one healthy, the former should for the same reason be extracted in preference.

If a tooth must be lost, either to allow a more important one to fall into line or to create space, it should be done without delay to accomplish the best results.—When a cuspid erupts without room in the arch for its accommodation, and the circumstances of the case point to the extraction of the first bicuspid to make place for it, the sooner the extraction takes place the better. If the operation be delayed, the cuspid in its endeavor to force its way into place will often press so hard upon the lateral as to force it inward, and if possible under the central, thus creating an additional irregularity. Such results have often been noticed. Prompt extraction after it had become necessary would have changed the condition.

In similar manner, when it becomes advisable to extract one or more of the first molars to prevent the further expansion of the jaw or to abort a threatened irregularity in the anterior part of the arch, it is best not to delay their extraction too long. They should not be extracted before the second bicuspids are in place, but if they must be lost, they should be removed after the eruption of the latter teeth and before the second molars are in place, somewhere about the eleventh or twelfth year. If longer delayed, the harm we wished to prevent (expansion of the jaw) will have been done and their later extraction will not avail. If extracted about the time that the second molars are erupting, the latter will glide naturally into the space formerly occupied by the extracted teeth; this they are not so apt to do later on.

If a tooth must be removed on one side to obtain space, it does not necessarily follow that its opposite mate should also be extracted.—If there be the same reason for extracting both, as where the existing evil pertains as much to one side as to the other, let both be extracted; but where the trouble sought to be remedied is confined to one side, the extraction of a tooth on that side ought not to be supplemented by a useless extraction on the opposite side. Those who favor symmetrical or double extraction claim that it prevents the disturbance of the median line, but it is our experience that the extraction of a tooth back of the cuspid

will not often affect the central line through the moving of the teeth toward the space, and even a slight disturbance of that line is, to our mind, far less objectionable than the sacrifice of a valuable tooth.

Where there is disparity in size between the two jaws, and two teeth need to be extracted from the more prominent one, it would be a serious mistake to extract also the corresponding teeth in the other and smaller jaw.—It would seem almost impossible to make such a mistake, and yet that it has been made time and again the mouths we are called upon to examine often bear sad evidence. It occurs through lack of knowledge, want of judgment, or erroneous teaching.

When those of long practice, who should know better, write in the public journals advising that at eleven years of age the four first molars should be extracted, without qualification, it is scarcely to be wondered at that some young practitioners should lose confidence in their own better judgment and be led astray. Harm of this nature, when once done, can never be undone, and the patient is injured beyond repair.

If appearances indicate that certain teeth may have to be removed at some time before the case is completed, though not in the beginning, perform all the work possible first, and then extract if necessary. In many cases it appears as though the arch would not only need expanding, but that one or more teeth would have to be removed. Instead of extracting first, and then expanding, it is better to expand first; and it may then appear, as it often does, that our object can be fully accomplished without resort to extraction at all. Were we to pursue the other plan, good teeth would sometimes be sacrificed.

Needless extraction should be carefully guarded against.—It is our object to save and improve, and not to destroy. Extraction should only be resorted to when it appears, after careful consideration, to be the only or best way of accomplishing the object in view. Ill-advised extraction of the molars or bicuspids has often been the cause of a very serious and irremediable form of deformity—namely, the separation of the anterior teeth from one another, leaving unsightly spaces between them, thus depriving them of their natural support and leading to their earlier loss.

When teeth, especially the first molars, are extracted at a later period than they should be, leaving a space that the second molars cannot occupy, the teeth anterior to the space will fall back unless prevented by the occlusion. If this falling back pertains only to the bicuspids, no harm will usually result, but if it extends to the anterior teeth, as it may and often does, the result will be disastrous. In this connection we cannot help again emphasizing the necessity for the removal of first molars (if they are to be removed) before the second molars have assumed their place in the arch.

If a crowded arch calls for or will admit of expansion to advantage, do this in preference to extracting.

When a case presents for treatment, the first thing necessary is to carefully examine the patient's mouth: notice the general condition of the teeth, the extent and character of the irregularity, and the occlusion of the two jaws. In addition to this, if the irregularity is of any con-

siderable extent or if there is disparity in size between the two dentures, or one of them is misshapen, it is most important to study carefully the harmony or inharmony of the patient's features and the character of the expression.

This is perhaps the most important part of the study of any case, and is that which we cannot at all get from a study of the plaster models alone. Usually, several ways of correcting an irregularity will suggest themselves in the study of the case, but the proper one to adopt can only be decided by an examination of the features. If there be any marked peculiarity of the case, as the malformation of a denture, it is well also to inquire as to its possible heredity upon the side of either of the parents; for this may have its weight. After this examination of the case the further study may be prosecuted from articulated plaster models of the jaws.

The personal examination will usually decide the advisability or non-advisability of an operation, and also the general character of it as determined by the features and other associated conditions. The future study of the models will enable us to decide upon the means best adapted to bring about the desired condition. It is also important, at this first interview, to take a correct impression of both upper and lower dentures. The old method of doing this, by having the patient close the jaws upon a mass of wax, and then using this to obtain both models and articulation from, is objectionable, as it does not give us a true impression of the teeth on their palatine or lingual surfaces, which is all-important.

The proper way is to select a britannia impression-cup with flat bottom, a little larger than the size of the arch; place upon this a sufficient mass of modelling compound (Godiva or Stent's composition), previously

Fig. 192.

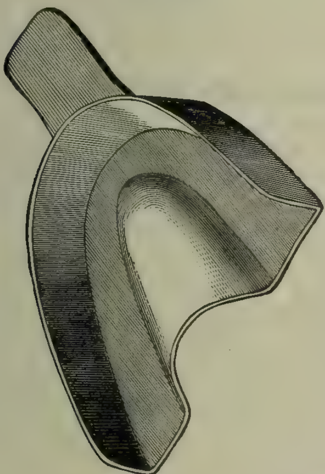
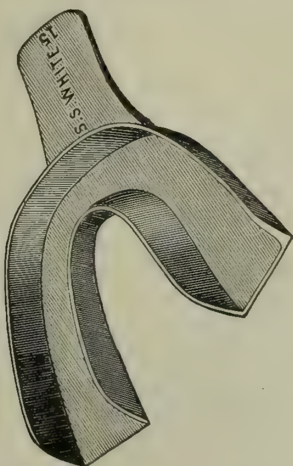


Fig. 193.



Impression Cups.

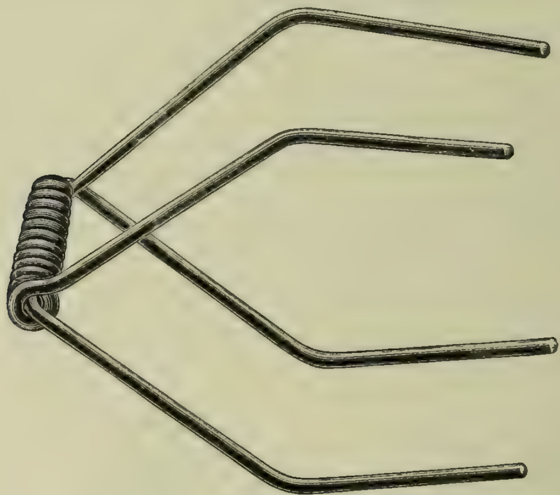
softened in hot water; insert this carefully into the mouth and press it up into position; then, holding the cup firmly there, press the mass of material that has appeared outside of the teeth against their labial sur-

faces and the gum adjoining. Retain all in position for three or four minutes, or until the material is difficult to indent with the finger-nail; then remove. Figs. 192 and 193 represent the form of metal trays alluded to, both upper and lower.

By the use of the compound we get an impression excelled only by plaster in minute detail, and obtained with far greater ease. After obtaining the impressions we should observe whether the natural teeth articulate normally or abnormally; if the latter, we should make a note of it. This will take the place of an articulating bite, and enable us to place the models, after they are obtained, in their proper relative position to one another.

A very simple and neat articulator for holding the models permanently in their proper position is shown in Fig. 194. It is made of

Fig. 194.



Wire Articulator.

brass wire, and is easily constructed. The upper arms and spiral are one continuous piece. The lower arms are another piece of the same wire passed through the spiral and bent to suitable angles.

The models (upper and lower) are saturated with water and placed in their proper position relative to one another, as indicated in the notes. They are then placed between the upper and lower arms of the wire articulator, and by means of a soft batter of plaster the upper arms are united to the upper model. When the plaster has set, the whole appliance is inverted, and the lower arms are in like manner joined to the lower model. This method gives us perfect models and a hinged articulation light in character, enabling us to notice the occlusion of the inner cusps as well as the outer ones.

Having the articulating model, our more thorough study of the case in all its details should be proceeded with deliberately. In so doing, and in deciding upon the form of appliance to be used, we will have to consider the age of the patient; for, while a method which gives us

little force or power will usually be sufficient to move teeth in young jaws, in older ones a device may be needed that will operate more powerfully.

The constitution or general health of the patient at the time will also have to be considered. If the health be good, we may proceed with good prospects of success; but if it be poor—that is, if the vitality be low—it may be better not to begin operations until a time when the patient has grown stronger. Under any condition of health we may be able to succeed in what we wish to accomplish, but it may also be done at the expense of more important matters. The physical and nervous strain in these operations must not be underestimated or lost sight of, and an improvement in the denture will not compensate for impaired health.

Considerations of sex have something to do with deciding when to begin treatment. With a boy, if the health be good, we may begin at any time. He is, by nature, stronger than one of the opposite sex, and subject to no debilitating period. With a girl, however, it must be borne in mind that the age of thirteen or fourteen, just as she is passing from childhood to maidenhood, is a critical period of her life, and her system is undergoing a change very debilitating in its character. To further tax her strength with any extended operation for irregularity at this time would be manifestly unwise. It should either be begun earlier or delayed until later.

Another matter to be taken into account is the efficiency of the change to be brought about. If, even with the teeth out of proper position, the patient has been able to articulate and masticate well, we must see to it beforehand that after the change has been made the occlusion of the jaws will be such as to give results at least equally as efficient as before the operation. Malposed teeth that perform the duty of mastication well are often preferable to a symmetrical arch with a poor occlusion.

Finally, we must consider whether the change wrought will be permanent or not. With young and newly-forming processes there is usually no doubt as to any reasonable change being permanent, provided the retaining appliance is kept on long enough. With those older, however, this is often a matter of great uncertainty.

Some few practical hints, founded upon experience, may not here be out of place in helping others to decide as to the method of procedure.

If the anterior teeth are to be moved backward in the arch, instead of trying to move several it is better to move but one on either side at a time, beginning with those farthest back, and coming forward. It may take longer to do this, but less power will be required, and there will be, in consequence, less danger of disturbing or moving the points of anchorage. If both front and side teeth are to be moved outward to enlarge the arch, move the side ones first. If the order be reversed, the front teeth will be apt to fall back from lack of support while the side teeth are moving.

Use the simplest means in your power for the accomplishment of the end in view.

Try to select the best method before you decide to adopt any.

After selecting the method which seems best for the case under consideration, test it for the possession of the following qualities:

1. Efficiency;
2. Simplicity;
3. Causation of minimum of pain and inconvenience;
4. Rapidity of action;
5. Least interference with speech and mastication;
6. Cleanliness;
7. Inconspicuousness;
8. Stability;
9. Non-injury to tooth-substance.

Probably no appliance or device can combine all of these desirable qualities, but that which combines the greatest number of them will be the best one to adopt.

Specific Forms of Irregularity, and their Treatment.

In passing from the consideration of general principles to their practical application it will be most convenient to arrange them under the head of classes or types. We propose, therefore, to consider—

1. Anterior teeth erupting outside or inside of the arch;
2. Anterior teeth outside or inside of arch after dentition is complete;
3. Misplaced bicuspids;
4. Torsion;
5. Alteration of form of arch;
6. Protrusion.

Anterior Teeth Erupting Outside or Inside of Arch.—*Inferior Incisors* (one or several) may assume positions either inside or outside of the regular line of the arch. If they erupt inside, we must remember that they are intended to erupt inside of the temporary ones, and when they stand abnormally inside they have usually been deflected from their proper line by the too long retention of their deciduous predecessors. Their correction, so far as it may be advisable at the time, may usually be accomplished by the removal of the deciduous teeth that they supplant and by frequent pressure of the patient's finger from within. This may not bring them entirely into line, but gradually, with the natural expansion of the process, they will usually come quite or nearly into their proper places. When they erupt outside of the arch, or in any way get there, they are usually prevented from coming into proper position by the malocclusion of a superior incisor. In such cases by bringing the superior incisor forward into its proper position the inferior one will usually be forced back into line.

If, however, it should occur, as it sometimes does, that from causes not discernible the lower incisors become crowded and overlapping, and show a strong inclination so to remain, it is good practice not to interfere until all the permanent teeth are in place, after which we may extract an incisor and draw the others together to close the space.

Superior Incisors are apt to give us very much more trouble than their fellows in the lower jaw. We find more noticeable irregularity

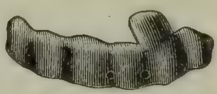
among them, and find it harder to correct. The most common form of irregularity which presents itself is that in which the two centrals or laterals (usually the latter) fall inside of the corresponding teeth below. This is sometimes noticeable as soon as the erupting superior lateral meets the cutting edge of the lower one. Very often at this point the difference between the superior tooth biting over the opposite one or under it is very trifling.

Shall we allow this tendency in the wrong direction to go on and increase until all the permanent teeth are in place, because some have taught that regulating should never be attempted until dentition is completed, or shall we interfere just at this point, and by slightly changing the direction of both teeth (usually one only) prevent an unsightly deformity in each jaw? Certainly, good judgment would dictate the latter course. It is easy to do now; it will be harder later on, when the cuspids have come in and monopolized part of the room intended for the laterals.

There are many ways of bringing these teeth out into line. If there be but one lateral or central inside the arch, the simplest appliance to effect the purpose is the "inclined plane" or "saddle."

It was originally made of silver plate, swaged to fit and cover the lower incisor crowns, with pieces of heavier silver set at an angle and soldered to the top ridge. In closing the jaw the offending tooth struck this inclined plane, and by the force of continued occlusion was gradually forced out into line (see Fig. 195). The objections to it were that it was difficult to keep in place, and was liable to be swallowed or lost or "removed for cause." Later, it was made of rubber, which, being closely moulded to the shape of the teeth, kept its place better.

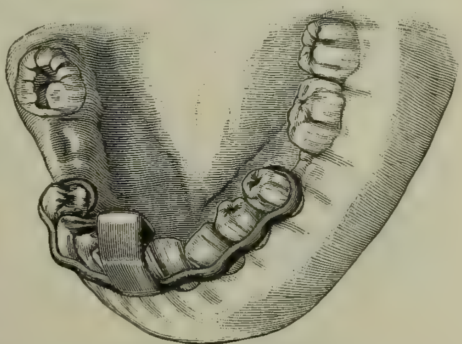
Fig. 195.



Inclined Plane.

A different way of making the attachment of the plane to the natural teeth is shown in Fig. 196. It consists of a half-round silver wire bent to conform to the outline of the lower arch and having clasps fastened to its ends. These clasps attach it to suitable teeth farther back in the mouth and keep the fixture in position. At the point where the inclined plane is wanted a saddle made from silver plate, and shaped to fit over the cutting edges of one or more teeth, is soldered to the wire. To the ridge of the saddle is then soldered the heavy metal inclined plane. This fixture is eminently practical, and is in constant use by many practitioners.

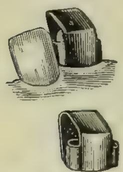
Fig. 196.



Inclined Plane Mounted on Wire.

Still another form of inclined plane, devised to meet those cases where patients were more than likely to remove any movable fixture the minute

Fig. 197.



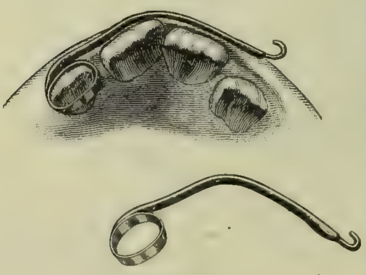
Fixed Plane.

your office-door closed after them, was originated by the writer. It was also intended to be double acting, by bringing the lower tooth in at the same time that the upper one was being brought out. Fig. 197 shows it in position and separate. Its construction is entirely simple. A band of thin platinum plate (No. 29 Am. gauge) is bent to encircle and fit the protruding lower incisor, and the ends soldered. To this is soldered a piece of ordinary plate gold bent double to form the plane, and then spread apart at its terminal ends to grasp the band on the palatine and lingual surfaces, to which it is soldered. It is then tried on the tooth to see that it has been correctly constructed, removed, lined with zinc phosphate, replaced quickly, and pressed into position. If it pass tightly between the teeth, a mallet and piece of pivot-wood will quickly send it home. If it be not intended to move the lower teeth in, the platinum band is made to encircle two teeth and applied in the same way. The cement not only lines the band, but fills up all the space between the plane and the tooth, thus giving greater resistance and strength in biting. Its advantages are its small size and its absolute fixedness. The writer has never been able to remove one after its work had been completed without cutting the band in two.

It has been urged against the use of all inclined planes that they prevent the occlusion of the other teeth, thus permitting them to elongate; also, that the patient will cease to bite upon the moving tooth as soon as it becomes tender. The writer has for many years largely (almost exclusively) used the inclined plane in one of its forms for cases such as the above, and he has never found either of the above objections to be sustained. The posterior teeth would certainly elongate if kept apart any considerable length of time, but as experience has shown that a single tooth can thus be moved into line in from one to three weeks, the time is too short for trouble to ensue.

It will be borne in mind that reference is now had to young teeth partially or fully erupted. Were all the teeth in place and the age of the patient greater, the use of the inclined plane would not be indicated, for then it might fail to perform its work, or do it so slowly as to permit elongation of the posterior teeth. As to the second objection, it will be found on trial, we think, that the patient will bite upon a sore tooth rather than go without solid food. If, however, for any reason, it be desired to bring out the superior laterals without making use of the lower ones for that purpose, it can be done in several ways. A very good way is shown in Fig. 198. In this case a girl of ten had both laterals inside of the arch, this condition being complicated with crowding of the centrals, so that the right central was slightly turned in its socket and somewhat overlapped the left one. The appliance consisted of a

Fig. 198.



Spring Bar.

platinum band to encircle the right lateral, with a bar of spring gold strengthened with solder attached to it, and extending over the front teeth far enough to cover the left lateral. At the free end the bar was converted into a hook, and in its course it touched only the prominent edge of the twisted central. The fixture was then, by means of the platinum band, cemented to the right lateral, and a rubber ring passed over the free end and the left lateral. It thus operated in two ways: first, to bring the laterals out into line, and next to press backward and inward the protruding corner of the central. It did its work satisfactorily in a few weeks' time, after which the central was further straightened with another appliance.

Another plan of moving outward any or all of the superior incisors is by means of a plate constructed after the pattern of Fig. 199. It is made of rubber, and has inserted in it a half-round gold wire with the flat side toward the teeth. This wire passes out from the plate on one side in the space left by the shedding of the deciduous cuspid, and, following the outline of the teeth, but separated from them by a space of an eighth of an inch or more, enters the plate at the corresponding point opposite. When in position pressure is brought to bear upon the teeth to be moved by means of rubber bands passing over the gold wire and around each tooth. The cut shows the manner in which these bands are used. The one with the single fold to encircle the tooth is used where less traction is desired, but the other, with the double fold, will have to be used to bring the tooth entirely in contact with the wire. To prevent, as far as possible, the bands from slipping off over the cutting edge of the teeth, the wire should be so arranged in relation to the plate that when in position it will be on a line with the necks of the teeth, thus enabling the rubbers to pull upward as well as outward. Should the rubber bands still show a disinclination to remain on the teeth, they may be held in place by a ligature tied around the neck and joined to the rubber on the palatine side.

Fig. 199.

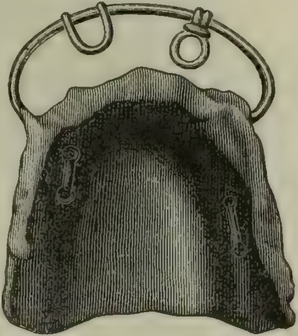


Plate and Bar with Rubber Rings.

The plate is secured in its position by being ligated to a tooth on either side, preferably a molar, holes being drilled in the plate for that purpose at suitable points. If, when the teeth are moved out far enough to touch the gold wire, it be desired to move them still a little farther, the bar can be stretched by beating it with a riveting hammer over the horn of a small anvil.

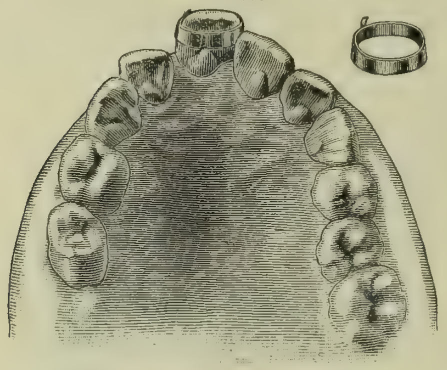
If these teeth, on being brought into position, are not retained there by the natural occlusion, a plain rubber retaining plate, fitting the palatine arch and necks of the teeth, may be worn for several months.

Still another way of moving these teeth outward, and the lower as well where necessary, is by the use of the Coffin plate constructed upon the plan of the one shown in Fig. 190. The only difficulty in the use of the Coffin plate met with by the writer has been in reference to the

moving of the teeth under consideration. The plane of the inclination of the palatine surfaces of the superior incisors is usually so far from the perpendicular that the free end of the wire, after being pressed up into position on the tooth, is frequently thrown down toward the cutting edge by the force of the spring. Where great inconvenience has arisen from this cause the writer has been accustomed to remedy it by cementing a narrow platinum band about midway of the tooth to be moved, and placing the end of the wire above this.

Superior Incisors standing Outside of Arch.—This condition is much less frequently met with than the irregularity just described; still, it does occur, either through a strange persistence of the temporary incisors or through tardy eruption. Fig. 200 shows a very marked example of this kind of irregularity. It was probably caused by delayed eruption and the consequent partial closure of the space by the adjoining teeth. The cut is taken from the model, but the latter was made from an impression taken after the adjoining teeth had been wedged apart. In the beginning the space between the left central and right lateral was considerably smaller. It was in the mouth of a girl about twelve years of age. The space was enlarged by the action of compressed wooden wedges, and the tooth brought into place by the use of a rubber plate, platinum band, and section of rubber tubing. The plate was made to fit and cover the roof of the mouth, as well as that portion of gum lying between the separated teeth. This plate had formed on it a little prominence or button at a point about midway between the right second bicuspid and median line. The platinum band, with a headed platinum pin soldered to its front face, was cemented to the protruding tooth. Between the rubber button and pin on the platinum band a rubber ring extended, passing on each side of the central.

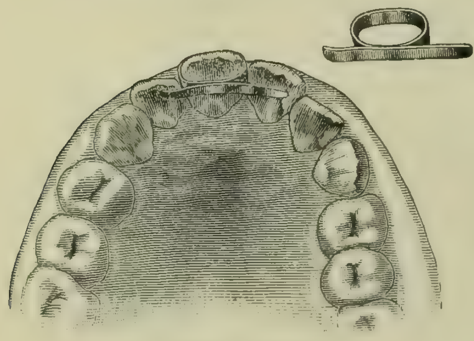
FIG. 200.



Metal Band for Attachment of Rubber Rings.

The tooth was brought into line in a few weeks' time, and was retained there some six months, until firm, by the little fixture shown in Fig. 201. It is simply a platinum band encircling the tooth, with a small gold bar attached to the palatine side

FIG. 201.



Retaining Band.

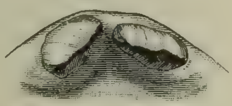
touching the adjoining central and lateral. It was cemented to the tooth. The advantage of so small and simple a retaining fixture is that it is quite inconspicuous, scarcely perceptible to the tongue, does not interfere with speech, and being fixed cannot be lost or mislaid,—all important considerations to a child attending school.

Closely related to or associated with this outstanding of one or more of the superior centrals is a certain amount of torsion, the twisted tooth being sometimes crowded and sometimes having spaces upon one or both sides. Figs. 202, 203 well represent each kind. With the exception that where interdental space exists it must first be closed by connecting the teeth with a ring of rubber tubing properly secured, their treatment is exactly similar.

FIG. 202.

Torsion and Overlapping.

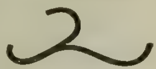
FIG. 203.



Torsion with Space.

As before hinted, and as will be readily seen, all appliances for the reduction of irregularity during the "school" age should be as small and light in character as possible, on account of enunciation, and they should at the same time be as painless as possible. Rubber plates are cumbersome, and rubber ligatures often unstable. To meet these conditions a little device for the correction of slight torsion of the superior incisors was devised by the writer, and has been used for many years with great success. Its appearance is represented in outline by Fig. 204. It is constructed from a strip of platinized gold about the thickness of an ordinary tooth-backing or "stay," in width about an eighth of an inch, and slightly longer than the joint width of the tooth to be turned and its neighbor. The strip is first bent midway of its length to form an angle, so that one slope shall fit the palatine surface of the tooth in position and the other reach across the space and touch the turned tooth at its distal angle. Each end of the strip is now bent to partly encircle and tightly hug the disto-palatine angle of each tooth. To this piece at its centre is soldered another strip of platinized gold of about the same width, but thinner than the first, and long enough to extend forward well beyond the prominent edge of the twisted tooth. At its extremity this piece is bent so as to embrace the protruding angle of tooth. By bending this arm so short that it will have to be sprung into place, pressure is brought to bear upon the tooth that will cause it to rotate in its socket.

FIG. 204.



Rotating Device.

The appliance should be removed each day, the length of the arm shortened by bending, and replaced. To guard against loss or accident a ligature of sewing silk should be tied around the neck of the tooth being turned and made fast to the appliance. About ten days will usually suffice to bring the tooth into line.

After being brought into place it is retained there as long as necessary by the little contrivance shown in Fig. 205. It is made by forming a platinum or gold band to fit each of the two teeth. These are tacked together with solder at the point where their circumferences touch, after which it is made stiffer by

FIG. 205.

Retaining Fixture.

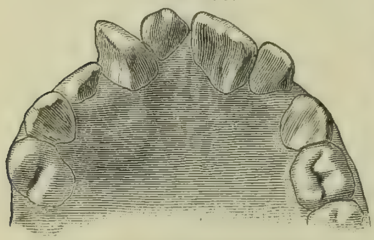
an addional strip of gold soldered to the palatine surfaces. When completed and polished it is lined with zinc phosphate cement and slipped over the teeth into place. By its agency the moved tooth is held so firmly and immovably in place that it becomes firm much more quickly than it would under other circumstances.

Another way of easily turning an incisor in the jaw of a young person is to fit a band or ferrule of gold or platinum to the tooth with a headed platinum tooth-pin soldered to its labial face near the angle that is out of line. A delicate vulcanite plate is then made to fit the roof of the mouth, and into it at a suitable point is screwed a threaded gold wire with a slight curve or hook on its end. After the band is cemented to the tooth it is connected with the hook in the plate by means of a rubber ring. These rings should be renewed every few days. Should it become desirable to change the point of attachment on the plate, it is easily done by drilling a new hole at the desired point and screwing the gold hook into it. Such a plate can be removed for cleansing and new rubbers attached by the patient as often as desirable.

Rotation of an incisor may also be very nicely accomplished by means of the Coffin plate. It should be constructed with a spring wire attached to the body of the plate and resting against the inner angle of the tooth, while another wire attached to that portion of the plate outside of the teeth rests against the outer angle. By this means we have pressure in opposite directions at the two angles of the tooth, doing the work rapidly and well. The treatment of a somewhat difficult case, involving both rotation and the bringing together of teeth, may be of interest in this connection.

The patient was a Japanese boy nine years of age, whose teeth when he was brought for treatment presented the unpromising appearance shown in Fig. 206. The left deciduous lateral was still in place, while the right permanent lateral was just appearing through the gum. Both permanent centrals had fully erupted, but, owing to the presence of a supernumerary tooth in the centre of the arch, the right central was crowded far out of its place and turned on its axis.

Fig. 206.



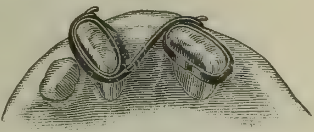
Torsion caused by Supernumerary.

After extracting the supernumerary and deciduous lateral the treatment was begun. The mechanical difficulties of the case would have been greatly lessened could treatment have been delayed until the bicuspids and cuspids were in place, for they would have helped serve as points of anchorage for the exertion of force in correcting the deformity. It was deemed inadvisable, however, to wait, because in a few years the arch would have been permanently enlarged, and after correction considerable space would have existed between central and central, and central and lateral.

As it was, the one central had to act as an anchorage in bringing the other into place. Two gold bands were constructed to fit the centrals. To the left central band there was attached a tooth-pin on the labial

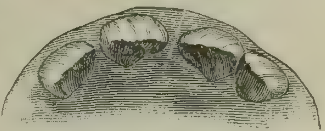
surface near the proximal border. To the other band was also attached a pin on labial surface near the distal border. After cementing these bands in place, a ring of elastic rubber was caught on the pin of the right central, passed around and back of it, and slipped over the pin on the other band. Fig. 207 shows the position of the teeth, with bands and rubber ring in place. In about a month the teeth were drawn nearly together, and the right one was also considerably straightened. Unfortunately, and yet not unexpectedly, in doing so the left one was slightly turned on its axis. An appliance was then made (described later on under Double Rotation) by which both teeth were brought into proper position. A double oval retaining appliance (Fig. 205) was then put upon them, and everything looked well. In a few days, however, it was noticed that while the teeth could not change their relation to each other, they were moving off in such a way as to form a tangent to the arch. This was caused by the effort on the part of the right central to move to its old position out of line, and in doing so turning its loosened neighbor. Without removing the fixture they were easily brought into position again, and as by this time the right lateral was almost fully erupted, advantage was taken of it to assist the others in keeping their place. To do this the retaining appliance was removed, and to its palatine surface was soldered a small spur of gold to reach to and rest against the palatine surface of the lateral, after which it was reset with cement. This remedied the difficulty, and in six months they were firm in their new positions, as shown in Fig. 208.

FIG. 207.



Bands and Rubber Ring for Rotation.

FIG. 208.



Corrected Case.

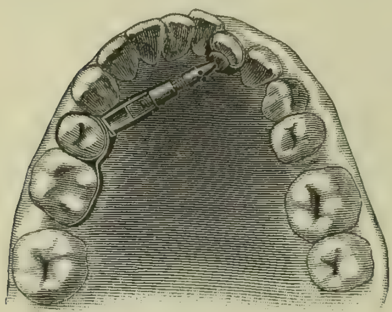
Anterior Teeth Outside or Inside the Arch after Dentition is Complete.—Cases of this kind do not differ materially in character from those we see before dentition is complete, but they are more difficult to correct, both because it is harder to obtain space for them after all the others are in place, and because the surrounding hard tissues are more dense and less yielding.

In the lower jaw the irregularity is usually limited to an incisor or two out of line, and usually within the arch. In the normal enlargement of the process these teeth failed to find room in the arch or failed to occupy it. They have now to be assisted into place. Most generally there is not enough room in the arch to accommodate them. If this be the case with two incisors inside the arch, it is usually better to extract the one we feel least hopeful of getting into line. By moving the remaining teeth in the direction needed we will usually have no difficulty in making place for the one still out of line. After space is secured the tooth can generally be best moved into place by the Coffin method.

Very often, however, there is but one tooth inside, and not enough room for it in the arch. In such case room must be made for it, either by expanding the arch slightly, or, more commonly, by wedging apart the adjoining teeth.

In some cases, however, it may seem advisable, as it has more than once to the writer, to save time by forcing the tooth into line and allowing it to make room for itself in the act. Fig. 209 will illustrate a case of this kind. A thin platinum band was made to fit the instanding lateral, and to it was soldered on its lingual side a tongue of the same metal, but quite thick. This tongue extended upward a little way toward the cutting edge of the tooth, and had a countersunk depression in it. It was cemented in place. A similar band (without the tongue) was made to fit the second bicuspid on the opposite side, and to keep it from moving, as well as to distribute the force of resistance, it had soldered to it a strip of heavy gold arranged to lie against and fit the lingual side of the adjoining first molar. To the bicuspid band was also soldered, at a point facing the opposite lateral, a small piece of heavy gold, into which a horizontal slot or groove was cut. This fixture was cemented to the bicuspid, and a plain fish-tail jackscrew was applied, with its flat end in the slot and its point in the countersunk hole in the band on the lateral.

Fig. 209.



Jackscrew forcing out Inferior Lateral.

The screw being turned daily by the patient with a curved instrument provided for the purpose, the tooth was brought into line in two weeks' time. It was retained in place for a month or more by means of a figure-of-eight ligature of fine platinum wire (No. 29 Am. gauge) passed around it and the two adjoining teeth.

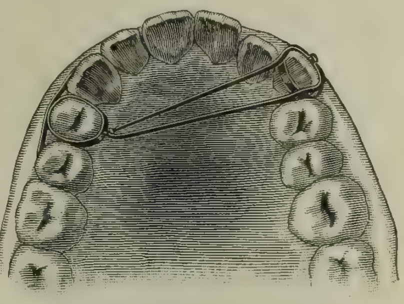
Any of the anterior teeth in the inferior jaw can be readily moved in the same way.

In the superior arch, when any of the teeth stand out of line, the first question arising is that of space for their accommodation. This can be provided, as in the lower, either by enlargement of the arch laterally or anteriorly, or both if the case will admit of it, or by the extraction of a tooth. If the latter is deemed best, the decision as to which one had better be extracted can best be reached by considering the rules governing extraction previously given. After room is obtained, if the tooth be outside the arch, it may be brought in by the Coffin plate and spring wire, or by the platinum band on tooth, vulcanite plate, and rubber band as described on p. 338. If the tooth be within the arch, it may be forced outward into line by the Coffin method or by the jackscrew with platinum bands on the teeth, or by means of the appliance described on p. 337. In the case of a cuspid located inside of the arch the jackscrew with bands would be the most powerful force to apply, and probably the best means of bringing it into line. When the cuspid is outside of the arch (a much more common condition), it may be brought in, after space has been provided for it, either by the use of an elastic rubber ligature or by the more powerful gold box and screw.

Two cases from practice will perhaps best illustrate each method.

Fig. 210 represents the upper jaw of a young lady of seventeen in which the left cuspid had never fallen into line, although there was room to accommodate it. A platinum band with pin on labial face was cemented to the cuspid. To the first bicuspid on the opposite side was fitted a similar band, with a small gold hook on the palatine surface and with a bar of clasp gold attached to the labial surface. This bar was made long enough to reach to and rest upon the adjacent cuspid and second bicuspid. This provided the resistance of three teeth, whilst attachment was made to but one. A light vulcanite plate was made to cover the arch to protect it from the irritation of the rubber ring, which was stretched across from band to band. The operation of bringing the tooth into line was somewhat slow, occupying some four or five weeks' time, but the object was satisfactorily accomplished.

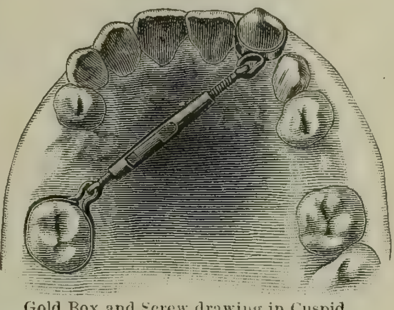
Fig. 210.



Metal Bands and Rubber Ring for drawing in Cuspid.

The other case is illustrated by Fig. 211. This young lady was about twenty-one years of age, and the laterals had never erupted. As the cuspid was more firmly implanted, owing to age, and as she was living some twenty miles away and could not be seen often, it was decided to adopt a means that would both furnish sufficient power and be under the patient's control.

Fig. 211.



Gold Box and Screw drawing in Cuspid.

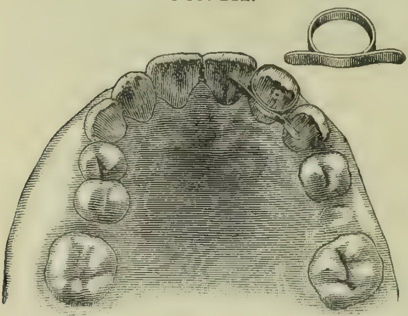
To meet these conditions the appliance shown in the figure was designed. It consisted of a square gold box about an inch in length and closed at each end. One end was drilled and tapped to fit a threaded gold wire about three-quarters of an inch in length, the smooth extremity of which was bent in the form of a hook to engage in a ring fastened to the gold band encircling the cuspid tooth. The gold box near its opposite end was open on two sides to admit of the introduction of a wire which passed through a hole drilled in this end of the box. The inner end of this wire was provided with an enlargement or head to furnish a swivel movement, while the outer end was converted into a hook to be caught into a ring fastened to a gold band surrounding the only molar on that side of the mouth. These bands, as usual, were cemented to their respective teeth, and when the box attachment was adjusted in place it required but the revolving of this box with a square-slotted instrument to give the required tension. The tooth was brought into place in about six weeks' time, the patient having been seen but five or six times during the operation.

It will be noticed in the illustration that this cuspid, besides being out of line, was also slightly turned in its socket. The ring fastened to the band surrounding it was therefore not placed in the middle, but to one side, so that the tooth should be slightly rotated at the same time that it was being drawn into place. The second illustration shows that both objects were accomplished.

Using a single molar to furnish all the resistance for the moving of a cuspid is usually bad practice, for very often it is insufficient, the molar being liable to move forward as much as the cuspid does backward.

In this case, with the means adopted, it was unavoidable, and fortunately worked very satisfactorily. The molar did move forward somewhat, but so little that after the operation was completed and the retaining fixture applied it quickly resumed its normal position, as shown in Fig. 212. The corrected tooth was retained in place by the small band and bar appliance shown in cut both in position and separate. The tooth in the preceding case was retained in the same manner. Six months sufficed for each tooth to grow firm in place.

Fig. 212.



Completed Case with Retaining Appliance.

Misplaced Bicuspids.— Bicuspids when out of position may be either outside or inside the normal line of the arch, or may be turned in their sockets. The latter condition quite frequently occurs, and will be alluded to under the head of "Rotation."

A bicuspid is seldom found situated outside of the arch, but is often found inside, it being forced to take that position usually by neglect to preserve its predecessor from decay. The deciduous second molar which precedes it is a larger tooth than the bicuspid, and generally after its extraction the bicuspid, finding plenty of room for itself, moves naturally into place. It not unfrequently happens, however, that the crown of the deciduous molar, weakened by decay, is broken off, while the roots are allowed to remain. In such case the retained roots deflect the coming tooth from its normal course, while the crowns of the adjoining molar and bicuspid incline to partly close the space. In nearly all cases the inward displacement of the second bicuspid is thus caused. The first bicuspid is not so frequently out of line, although both may be so placed. At times the superior bicuspids of both sides incline inward so much as to materially diminish the width of the palatine arch. In such cases the teeth remain in the line of the arch, but the shape of the latter is changed by forces outside of, and not associated with, the teeth themselves. When a single bicuspid is only slightly out of line, it may usually be brought in by wedging to make room for it, and then applying force to it in one of the different ways already described in connection with other teeth. As, however, any slight irregularity of a bicuspid, especially the second, is scarcely

noticeable, owing to its position, it is often advisable to do nothing to it unless it be causing injury or discomfort. In case of great deflection and tendency to unsoundness, it may be best to extract it, especially if the occlusion of the other teeth be normal and good. For the moving outward of either one or more of the bicuspids, either superior or inferior, we know of no better plan than the one devised by Dr. Kingsley and described in his work. We copy three of his illustrations, which are so accurate that they explain their own construction. Fig. 213 was used to move outward a left superior second bicuspid; Fig. 214 operated to move outward both bicuspids of the left side inferior, the first more than the second; while Fig. 215 moved all four of the inferior bicuspids. As will be seen, in all of these cases advantage is taken of the direct and forcible action of the jackscrew to move the teeth—a method that we thoroughly approve of and endorse.

Fig. 213.

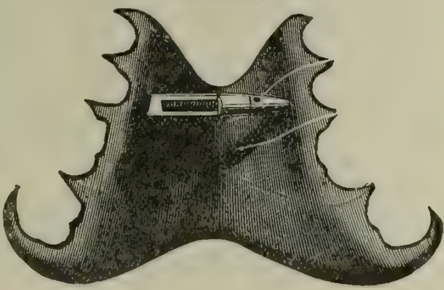


Fig. 214.

Fig. 215.

Kingsley's Slotted Vulcanite Plates with Jackscrew.

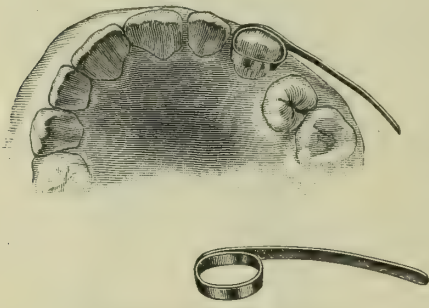
Torsion.—Torsion of one or more teeth in the mouth is a condition so commonly met with that it is a matter of surprise that those who have written upon orthodontia have given it so little attention. Tomes calls attention to the deformity, but mentions only one plan for its correction—viz. the swelling of compressed wooden wedges against the opposite corners of the turned tooth, these wedges being held in position and attached to a metallic band or rubber plate. Kingsley, besides describing Tomes's plan, mentions only one of his own, and that adapted to the turning of two incisors at one time. Prof. Stellwagen in his revision of Coleman's work gives this form of irregularity very complete and extended attention, while Dr. Farrar in his different articles devotes considerable space to it, although his plan is unnecessarily complex and unwieldy.

By the methods formerly in vogue the operation of rotating a tooth was so difficult as to constitute, as the writer well remembers, the *bête noir* of orthodontic practice. Not only was the resistance to be overcome greater in this operation than in the simple moving of a tooth in

one direction, on account of the greater amount of bone-structure to be pressed upon and changed, but the crown itself, with its rounded, polished, and moist surface, was difficult to grasp sufficiently firm for the application of the force necessary to accomplish the result. An easy and convenient means of doing this was lacking until Dr. Magill's device was brought forward. A swaged band or one fitted ever so nicely would hardly keep firm under strong rotary strain, but a band only moderately accurate in its adaptation would become a perfect fit when cemented to the tooth. The difficulty of the past had been removed by this happy thought, and it has since proven in the hands of the writer as in that of others almost a *sine quâ non* in regulating. The large part it plays in the writer's practice will be noticed in the illustrations.

This band, whatever the additions that may be made to it, is placed on the tooth about midway between the cutting edge and gum, so that if silk or rubber ligatures are attached to it they are kept there and cannot by any possibility either slip off the tooth or up on the gum to annoy and irritate—a thing that formerly seemed almost impossible of prevention.

Fig. 216.



Spring Bar and Band for Rotation.

Fig. 216 shows a case in which the band with gold arm attached was used to rotate a left superior cuspid. The end of the arm was tied down to a molar, and as the tooth turned the arm was bent outward with pliers without removal. The bar is preferred for the rotation of teeth as firmly set as the cuspids on account of the immense leverage obtainable, but with incisors or bicuspids the same end may be attained without the bar by having pins or hooks on the band, and getting the traction from rubber rings attached at opposite and distant points. Fig. 207 on p. 341 illustrates the use of band, pins, and rubber ring for partial rotation. With this means of gaining a firm attachment to a tooth, and the application to it of force in any form that best suits the operator, we believe any tooth can be rotated that is capable of rotation. We say *capable*, because teeth are sometimes met with whose roots are curved quite abruptly in some portion of their length, and to rotate these would be manifestly impossible. Such a condition may be sometimes foretold by a careful digital examination of the process overlying the root, but most usually it is indicated only by the fact that the tooth does not yield to force which would usually be sufficient to move one of its kind.

The writer well remembers how in his earlier practice he undertook to rotate a cuspid and failed. A careful examination as to the cause of failure developed the fact that the root was badly curved. Had he made this examination, as he should have done, before instead of after undertaking the operation, the patient would have been

saved months of annoyance and the operator the mortification of failure.

The possibility of meeting with cases of this kind should, we think, if no other reason existed, be sufficient to condemn that other method of turning a tooth known as immediate or forcible rotation. The rotating of a tooth by means of a forceps is attended with so much risk of injury, either to the tooth itself or to the delicate pulp, that it would seem inadvisable for general recommendation or individual practice.

Double Rotation—While torsion of a single tooth is perhaps most commonly met with before all the permanent teeth have erupted, double torsion, especially in the central incisors, is generally found to exist after the second set are all in place. It is probably brought about by the force exerted by the two cuspids in their effort to make place for themselves. Its occurrence after second dentition is complete makes it more difficult to correct than it would be earlier. Most frequently, the torsion exists to the same extent in both centrals, and very often not to such an extent as to prevent their being brought into line without securing more space, provided sufficient force is applied.

The method first in use, so far as we are aware, was the rude one of passing two match-sticks through a ring of rubber, twisting the rubber between them, and then slipping it into position, so that the rubber would lie between the centrals, while one stick rested across their labial surface and the other against their palatine. It sometimes did the work, but generally it could not be kept in position.

After that came the plan of soldering a screw-cut wire at right angles to the centre of a small bar of gold and having a nut threaded to fit the wire. Another bar of gold similar to the first had a hole drilled in its centre large enough to freely pass the wire. In applying, the first bar of gold was laid against the palatine surfaces of the centrals, with the wire passing between them. Over this protruding wire was then slipped the second bar of gold, so as to lie against the labial surfaces of the teeth, and the nut screwed down. By the tightening of the nut it was sought to bring the bars of gold nearer together and thus rotate the teeth. The principle involved was correct, but the fixture had two faults which interfered with its practicability—viz. there was no means of keeping it in position, and the wire between the teeth took up too much room.

In the summer of 1874 the writer had three cases of double torsion of the centrals brought to him for correction. Feeling the inadequacy of the means then at command, he devised the appliance shown in Fig. 217. As all the patients were young ladies attending school, it was desirable that the fixture, besides being effective, should not be unsightly, should not annoy the patient, and should occupy so little space as not to interfere with distinct enunciation. It will be seen that all these qualities are combined in it.

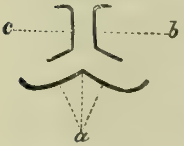
Fig. 217.

Device for Double Rotation.

The description of its construction is partly anticipated on p. 135 in connection with another appliance of the writer's nearly similar, but devised after the one now under consideration. The details of its construction are illustrated in Fig. 218. *a* represents the strip of platinized

gold ($\frac{1}{8}$ inch wide), fitted to the palatine surfaces of both centrals and passing around their disto-palatine angles. Two strips a little narrower than the first piece are then cut from ordinary gold plate, and bent in the form of *b* and *c* respectively. These are made long enough to be bent slightly over the labial surfaces of the teeth, extend along the mesial surface to the palatine, and then along this latter almost to the distal angle. After being properly shaped according to the model, they are clamped together and soldered along their contiguous surfaces. This part is then placed in position on the model, and the long arms bent to conform to the inner surface of *a*. After removal from the model the part *b–c* is clamped and soldered to *a* in proper position. The part *b–c* is then reduced in thickness by filing and the whole piece polished. A piece of rubber should be placed between the teeth for a day before applying the fixture.

Fig. 218.



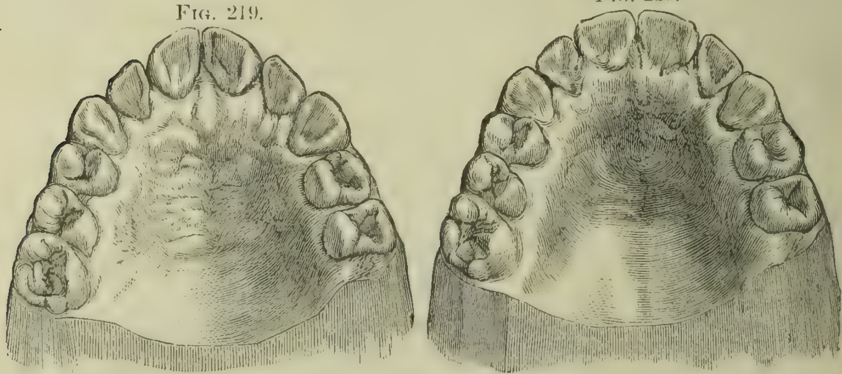
When properly constructed the labial part of the appliance will rest against the teeth just at or slightly above the most prominent part of their convexity, while the lingual portion will be near the gum, but not quite touching it, and the slightly curved ends of this part will catch just above the little prominence usually found at the disto-palatine angle near the gum.

When thus made and placed, the piece cannot become displaced by the action of the lip or tongue except when made loose by the moving of the teeth. As will readily be seen, by its use force is brought to bear upon four points of the two teeth at one time, acting as a double lever to each tooth.

In use, the patient should be seen each day, the fixture removed and tightened by bending the long arms slightly toward the smaller ones, and sprung into place. As a precaution a thread should be tied around the neck of one of the teeth and under the front bar.

In one of the three cases alluded to, the patient being seen every day,

Fig. 219. Fig. 220.

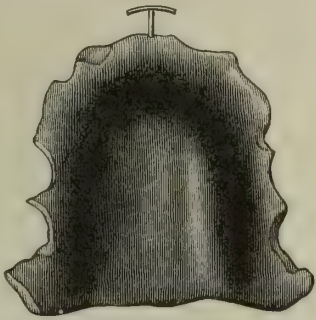


Illustrating Double Rotation of Centrals.

the teeth were readily brought into line in ten days' time. Fig. 219 represents her teeth before treatment, and Fig. 220 afterward.

The teeth after correction may be held for six months with a fixture as shown in Fig. 205; but as this occupies considerable room, passing through three spaces, the form shown in the annexed illustration (Fig. 221) is preferred. It consists of a gold T attached to an ordinary vulcanite retaining plate.

Fig. 221.



Retaining Plate.

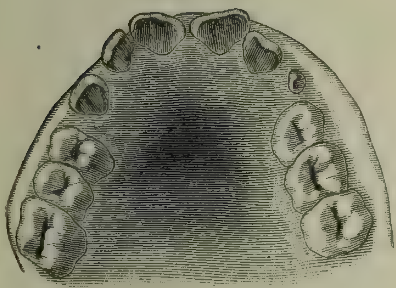
This same form of irregularity has been corrected by the writer and others by using a gold T with a long stem terminating in a hook. To this hook was attached a rubber band, which was caught over a projection or gold pin inserted in the middle of a rubber plate covering the roof of the mouth. As the teeth were rotated, the vulcanite plate was cut away in advance of them.

This appliance possesses value, but has not nearly the power of the gold appliance before described.

The double T-appliance can be used with equal effectiveness in cases where the teeth are turned in a contrary direction—viz. with their distal angles pointing outward and the mesial inward. In these cases the position of the appliance has, of course, to be reversed, the long arm or band being fitted to the labial surfaces and the short one to the palatine.

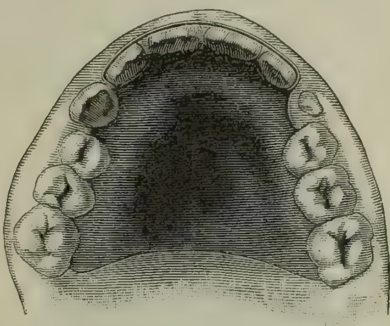
Fig. 222 represents a case of this kind corrected with the appliance just described, while Fig. 223 shows the same case after correction,

Fig. 222.



Torsion of Centrals, with Distal Angles pointing Outward.

Fig. 223.



Retaining Plate on Corrected Case.

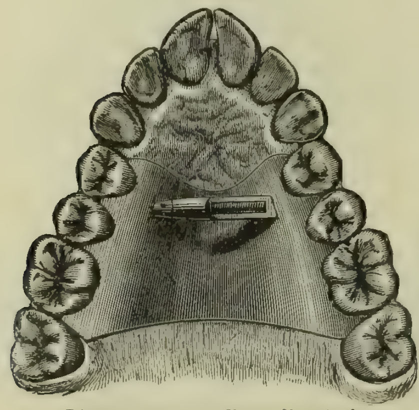
together with the appliance used to retain the teeth until firm. This latter consisted of a plain rubber plate to which was attached a fine gold wire, closely fitting the labial surfaces of the four incisor teeth, and passing in for connection with the plate between the laterals and cuspids. For another case of the same kind a simple double band (as shown in Fig. 205) cemented to the teeth was used as a retaining appliance.

Alteration of Form of Arch.—The deviations in form from a normal standard of the maxillary arches are usually confined to two classes. The one commonly known as the "V-shaped arch" is where there is

the normal width between the last superior molars, but a gradual narrowing of the arch from there forward, until at the median line the two sides meet at a sharp angle instead of a curve. The teeth in such cases, if there be no other accompanying irregularity, describe a nearly straight line on either side from the maxillary tuberosity to the median line in front. The other is commonly designated the "constricted arch," and differs from the well-formed arch in being constricted or contracted in the region of the biscuspid or first molar teeth. This constriction is sometimes so pronounced as to allow but half an inch of space between certain teeth on opposite sides of the mouth. In connection with this narrowing of the arch at one point there may be an angle in the region of the incisor teeth or they may describe a normal curve.

The causes accountable for either of these conditions have never been determined, some claiming that they are hereditary, while others hold to the view that they are caused by pressure of the buccal muscles on the sides of the arch while the mouth is open either in thumb-sucking or during sleep. Mr. Tomes from his observation has associated this form of arch with enlarged tonsils, which, he says, causes the person to keep the mouth open during sleep to aid in breathing. Both conditions, the "V-shaped" and the "constricted," are probably attributable in some cases to heredity, and in others to the bad habits or pathological conditions above mentioned. In regard to their correction, we would say that it should be begun as soon as all the permanent teeth are in place or as early in life as it is met with. The remedy must be mechanical, for it cannot be self-corrective. If the V-shaped deformity exists in the upper arch (it is seldom found in the lower) alone, and the lower be normal, we can best correct it by spreading the arch at the sides and drawing in the front teeth. The widening at the sides may afford sufficient room for bringing the front teeth into proper line without resorting to extraction. At all events, even if it at first seems necessary to extract, it had better be postponed until the arch is widened, and we may then find it unnecessary. With the constricted arch, if the front teeth form the normal curve, and those farther back by virtue of their constriction bite inside the lower denture, it will only be necessary to widen the arch and bring about natural occlusion.

FIG. 224.



Direct Pressure for Expanding Arch.

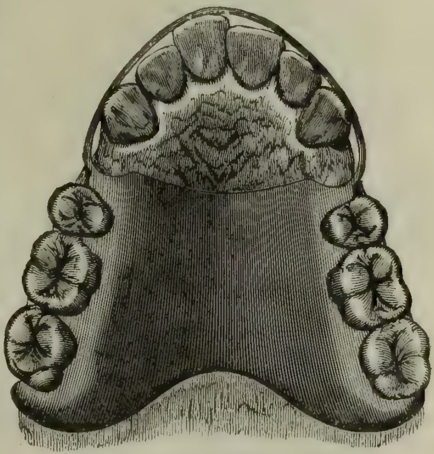
The arch may be widened by the use of a rubber plate and jack-screw, as shown in Fig. 224, or by the use of the Coffin split plate, as illustrated in Fig. 187, p. 320.

After widening the arch in the V-shaped class, the front teeth can be drawn back in several ways. If there be not too much resistance on the part of the teeth, we may some-

times use a rubber plate fitting the roof of the mouth and a gold T passing between and to the front of the central incisors, the two being connected by rubber rings.

Another way, novel and effective, was devised and used by Dr. Kinglsey. It is shown in Fig. 225, and thus described by him: The plate was accurately adjusted to fit and catch between the bicuspids and molars. The gold wire in front was elastic and springy. It was bent so as to impinge upon the incisors, then caught in front of them, pulled back, and sprung into place. The bending of the front wire has to be repeated every day or two until the teeth are retracted.

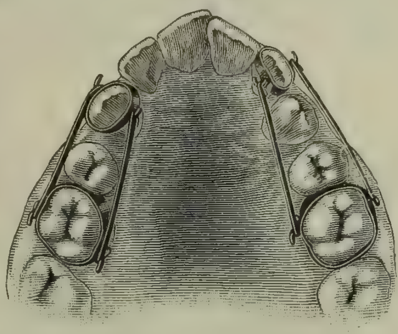
Fig. 225.



Gold Band and Rubber Plate for Retracting Anterior Teeth.

The writer has found it so difficult in his experience to move six teeth at once that he seldom attempts it. His own plan is to draw back one on each side at a time until all six are in proper position. One means of accomplishing this is shown in Fig. 226. Platinum bands with hooks attached are cemented to the teeth farthest back in the mouth, so as to obtain the resistance of all in front of them. Similar bands are attached to the two teeth (one on each side) to be moved. The hooks on the molar bands point backward, while those on the anterior teeth point forward. Rubber bands are stretched from hook to hook on either side, and do their work without irritation and with reasonable celerity. No plate is needed, and so the palate is left uncovered.

Fig 226.



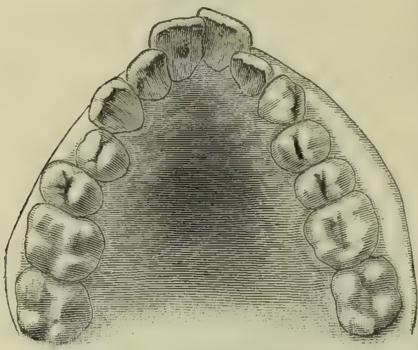
Retraction without Plate.

A case presented in the writer's practice a few years since in which, as will be seen by the cuts, there was great prominence and outstanding of the two centrals. The laterals were about in line, and all the rest of the teeth articulated beautifully with the lower ones. There was not room between the laterals, as they stood, to accommodate the centrals.

The young lady a few years before had been placed in the hands of another practitioner to have the deformity corrected. He had attempted the general spreading of the arch to make room for the centrals. Of the means or appliances he used we have no knowledge, but the treatment caused her so much suffering that her guardian removed the appa-

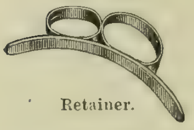
ratus and the treatment was discontinued. The right central incisor had become devitalized and had been treated; bleaching also had been attempted, but had ended in failure. When first seen by the writer the central (Fig. 227) was black as ink and open and decayed from apex to crown. To save the tooth was impossible, so it was decided, after a careful study of the case, that the loss of the tooth instead of being, as under ordinary circumstances, a calamity, would in this case be a means of simplifying the reduction of the deformity. The tooth was therefore extracted and the correction immediately begun. A platinum band with headed pin was cemented to the remaining central, and another band with pin attached to the first bicuspid of the opposite side. A rubber ring passing from one to the other brought the outstanding tooth into line in a few weeks' time. This did not entirely fill the space, so the two laterals were drawn in slightly in similar manner, and the space was closed. A retaining fixture was then made and applied, as shown in Fig. 228. In its construction two platinum bands were made, one to fit the central and the other the right lateral. To the back of these was soldered a narrow strip of gold clasp-metal extending to and resting against cuscuspid and cuspid. The bands were cemented to the teeth; this kept the fixture in place and held the teeth immovably. In six months' time the teeth were firm and the fixture was removed. The case as completed is shown in Fig. 229. The whole expression of the patient's face was changed, and her appearance vastly improved. Although several years have since passed, the teeth remain as they were when the case was completed.

Fig. 227.



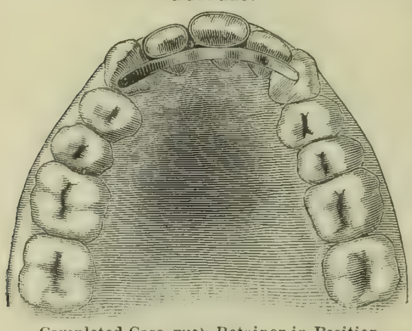
Protrusion and Crowding of Centrals.

Fig. 228.



Retainer.

Fig. 229.



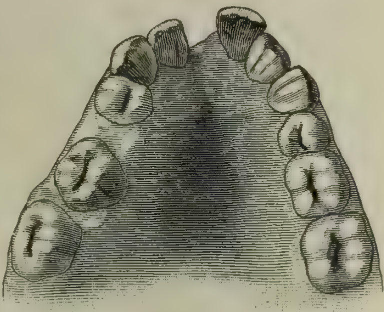
Completed Case, with Retainer in Position.

Another case almost identical in character was under treatment at the same time. The patient was several years older, and presented with the right central broken off to the gum. The root was good enough to pivot, but as there was prominence in the front part of the mouth, it was thought best to reduce this by extracting the root and treating the case after the manner just described. The same method was pursued with the same satisfactory result, although, as the patient was older (about twenty-three years of age), more time was consumed in its

accomplishment. As in the other case, the only teeth disturbed were the three incisors.

The jaw in this case differed from the former one in being constricted in the bicuspid region (Fig. 230). It was proposed to correct this by widening the arch, but the patient's appearance being now satisfactory to herself, she was unwilling to go to the expense of improvement farther back in the arch; and as her external appearance did not reveal the remaining deformity, further treatment was not insisted upon.

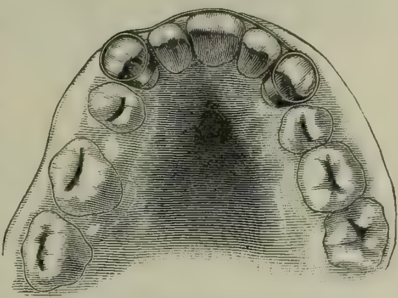
Fig. 230.



Protrusion with Loss of Central.

The retaining appliance in this case differed from the former one. Platinum bands were fitted to the two cuspids, and these were connected by a very thin platinum wire passing along and conforming to the outline of the labial surfaces of the incisor teeth, as shown in Fig. 231. The bands were cemented to the cuspids, and the fixture was worn some seven months.

Fig. 231.



Retaining Appliance in Place.

As none of the appliances or appurtenances used in the two cases touched the soft tissues, there was never any indication of irritation, and both patients declared that they suffered no pain in the course of the treatment.

Another class of cases, wherein there is no real change in the form of the arches, but where in the anterior region the one is spread out and enlarged, and the other somewhat retracted and flattened, is best known as the "thumb-sucking" variety. This habit, contracted very early in child-life, and sometimes continued until the eighth or tenth year, has doubtless been the most prolific cause of this deformity, and yet we often find the habit without the deformity, and as often the deformity without the habit. The condition is also frequently brought about by the practice of drawing the lower lip over the inferior teeth, closing the mouth, and sucking.

In cases of this kind, besides the inverting of the inferior and the everting of the superior incisors, the latter are usually found spread apart, with greater or less spaces between them. The condition is not only disfiguring, but tends to the gradual loosening of the anterior superior teeth and their early loss. The throwing out of the upper incisors gives them a relatively shortened appearance when looked at from the front, while the lower ones are relatively lengthened by being thrown in. As a result, it is frequently found in cases of this kind that the cutting edges of the lower incisors, instead of striking against the

lingual surfaces of the superior ones, strike into and irritate the gum back of these teeth. This is the more liable to occur since the molar crowns are usually abnormally short in mouths of this shape.

The first thing to be done in undertaking a case of this kind is to "raise the bite," so that the inferior teeth shall not touch where they did before. Various expedients have been resorted to and suggested to accomplish this result, but the simplest and most effectual one the writer has met with was suggested to him by Prof. E. T. Darby. It was based on the principle of elongation of the molar teeth. It consisted of a plain rubber plate fitting the roof of the mouth and having a ledge in front to receive the bite of the lower incisors (see Fig. 232). When in place, none of the teeth touched each other, but all the masticating had to be done on the front part of the plate with the lower incisors. This gave the molars an opportunity to elongate, which they did. The plate has usually to be worn about a year to accomplish the desired result. After this is attained, the lower teeth should be pressed out and the upper brought, in until the proper relation between the two is established.

Fig. 232.

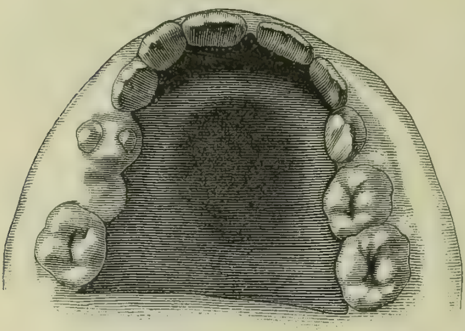
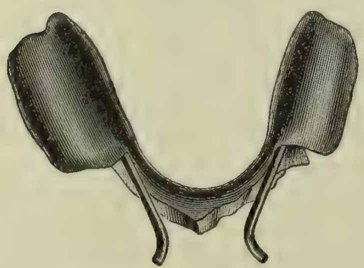


Plate for Elongation of Molars.

Not long since a little girl of eleven was brought to the writer by her parents to know what was to be done to break up the child's habit of "lip-sucking," as it was bringing on a deformity. They received the advice that if the deformity were corrected the habit would necessarily be broken up, as it would be no longer possible of accomplishment.

The case was taken in hand, and a rubber plate was made, as above described, to raise the bite. The plate was worn a whole year, after which the lower teeth were pressed out and the upper ones brought in. The lower teeth were the ones first operated upon. A Coffin plate was made to fit the inner surfaces of all the lower teeth, and in it were placed two piano-wire springs to press upon the laterals, as shown in Fig. 233. This plate was worn until the laterals were far enough out to be in normal position. Then an impression was again taken, and another plate of similar kind made, but with the springs to rest against the centrals. The object in making two plates, instead of changing the springs in the first one, was to have both, so that if it should appear after the centrals were pressed out that the laterals needed a little more advancing, it could readily be done by reinserting the

Fig. 233.



Coffin Plate for Lower Incisors.

first appliance. After all four teeth were out and satisfactorily in line a plain rubber retaining-plate was made. In drawing in the upper teeth a rubber plate with a small gold hook in the centre was made to fit the palatine arch. Platinum bands, with a pin on the labial face of each, were now made and attached to the laterals. Two rubber rings were then caught over the hook in the gold plate, and one drawn over each lateral. As they moved, the rubber plate was cut away to make room for them, and in a week or ten days they were in place. They were held by ligature to the plate. The same plan was pursued with the centrals until they were nearly in line. Then, as four bands took up too much space, those on the centrals were removed, while those on the laterals had each a gold arm attached to its labial face. To do this they were removed and reset. When in place a rubber band was passed under each arm until it arrived at a point between the teeth. It was then passed between the teeth and attached to the hook on the plate. In this way one band exerted pressure on two teeth, and by judiciously trimming the plate all were soon formed into a perfect normal curve, so that in closing the jaws the upper teeth passed over the lower ones without any space to spare. A retaining-plate was then made of rubber, after the Richardson plan. The habit, of course, was quickly broken up, and her features have become normal and harmonious.

Protrusion of the Jaw.—Protrusion is met with both in the superior and inferior arch. When there is prominence of the upper jaw, it may be from abnormal development of that part, or it may be only relative and caused by lack of development of the lower jaw or from injudicious extraction in the latter. In the individual person it may occur from hereditary influences. Protrusion of the lower jaw is perhaps more common than that of the upper. It is variously known as "jimber-jaw," "under-hung," and by the Germans as "Hundemaul," on account of the dog-like expression it gives to the countenance. It is one of the most repulsive of oral deformities and most difficult to correct.

In either kind of protrusion a careful examination should first be made to ascertain its character and, if possible, its cause.

Protrusion of the upper jaw, if it be real and not relative, can usually be corrected by widening the arch and drawing in the front teeth. If the arch will not admit of being widened, or if widening alone will not provide the room necessary, one or more teeth on either side posterior to the cuspids will have to be extracted to create space, after which the front teeth can be drawn in as far as may be necessary. If the protrusion of the superior teeth be only apparent or relative, owing to undue smallness of the lower jaw, the teeth of the latter will have to be spread apart or pressed forward, or the deformity cannot be remedied. In cases of this kind the patient appears to lack that most important factor of facial expression, the chin.

The methods for retracting the superior teeth when thus relatively prominent are the same as those heretofore described for retraction in other cases. The smallness of the base or body of the superior maxilla, from which the process shelves out in all directions, makes that process more easy of change in shape than the lower, where the base of the bone is as large or larger than the process resting upon it. In changing the

shape or position of the latter we must needs change the shape of the bone or the manner of its condyloid articulation, whereas in the upper jaw only the more pliable process needs to be altered in form.

In protrusion of the lower jaw our only reliance for correction seems to be in bringing pressure to bear upon the jaw, and either causing the condyle to articulate farther back in the glenoid cavity of the temporal bone or producing a change in the angle of the jaw.

To Dr. George S. Allen of New York is due the credit of first accounting for the change effected in retraction of the lower jaw, by the explanation that it takes place at the condyloid articulation instead of the angle of the jaw. Considering the thickness and solidity of the inferior maxilla at its angle even very early in life, it seems hardly probable that much if any change is made there by pressure in the mental region. It is far more rational to suppose that the pressure brought to bear upon the jaw from the front causes the condyles to recede in the glenoid cavity through absorption of its posterior wall.

The pressure applied to bring about any change of this character must be a retractor or sling possessing great power and capable of having its force graduated or regulated.

An interesting case of retraction of the lower jaw was brought before the Odontological Society of New York in 1878 by Dr. George S. Allen. I quote important points from his description: "As will be seen from the photograph (Fig. 234), taken at the time she was wearing this apparatus, it consists of two parts. For the lower part I made a brass plate to fit the chin, having arms with hooked ends reaching to a point just below the point of the chin. These arms were arranged in such a way that the distance between them could be altered at will by simply pressing them apart or together. The upper part consisted of a simple network going over the head and having two hooks on each side, one hook being above and the other below the ear. When this apparatus was completed and in use there were four ligatures of ordinary elastic rubber pulling in such a way as to force the lower jaw almost directly backward. The work proceeded very rapidly, so that at the end of two months the irregularity was almost entirely cured. I see no reason why in all such cases either this or similar methods of procedure should not be adopted. I should certainly, if any similar case presented hereafter,

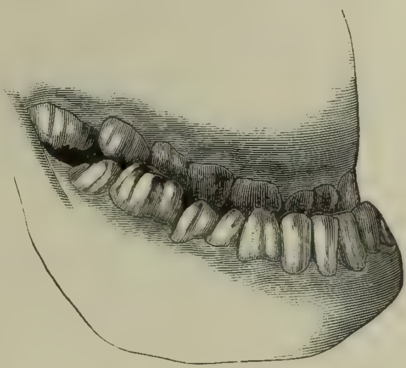
Fig. 234.

Retraction of Lower Jaw.

even at twelve or thirteen years of age, before attempting any other procedure try this first and thoroughly."

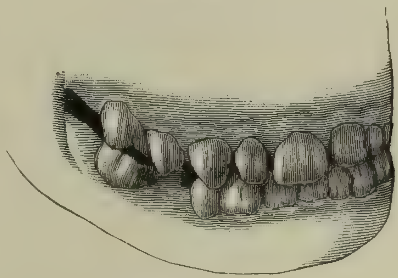
The Drs. Winner of Wilmington, Del., have furnished the writer with models and description of a case somewhat similar to the foregoing (Figs. 235, 236). In their case the patient was a boy fourteen years of age, tall, slender, possessing good general health, but only fair physical strength. The models show that there was a bicuspid lacking on each side above, while below there still remained two temporary molars. He stated that he had never had any teeth extracted by a dentist, so it is probable the two bicuspids were never erupted. The superior centrals were considerably worn away on their cutting edges and labial surfaces by attrition with the lower ones. After extracting the deciduous molars below, a plate was made covering the upper posterior teeth, and so arranged that in addition to furnishing a masticating surface while the teeth were apart, it also acted as an inclined plane in helping the lower jaw to move backward. From first to last he wore an occipito-mental sling, as illustrated in Garretson's *Oral Surgery*, increasing the tension from slight at first to as tight as could be worn without too great discomfort. At the end of nine weeks the articulation was normal, but the sling was worn for several weeks longer, without increased tension, to retain the satisfactory result secured.

FIG. 235.



Case of Protrusion.

FIG. 236.



Case Corrected.

Fig. 237 illustrates the most pronounced case of this class of deformity the writer has ever met with. The patient was a man of about forty years of age, and was brought by a neighboring dentist for consultation as to whether anything could be done to remedy the defect. The lower jaw was very large in all its aspects, while the

FIG. 237.

Excessive Protrusion.

upper was correspondingly small. Although the lower incisors inclined decidedly inward, in occlusion the distance from the cutting edge of the lower incisors to the cutting edge of the upper in a horizontal line was a little over half an inch. From the upper jaw there were missing the right lateral, second bicuspid, and first molar, while on the left side the second bicuspid and two molars were absent. In the lower jaw the patient had lost two molars and a bicuspid on the left side and the first molar on the right. All the teeth of the upper jaw passed inside the lower except the first bicuspids, whose external cusps articulated slightly with the anterior lingual cusps of the opposite molars below.

The advanced age of the patient, conjoined with the conditions just described, placed his case beyond surgical remedy, and he was so informed. A plate covering and masking the natural teeth above, with artificial teeth mounted outside to articulate with the lower ones, was suggested, but the idea did not please him, and he concluded to pass the second and shorter half of his life as he did the first, so far as appearance and mastication were concerned.

REPLANTATION AND TRANSPLANTATION OF THE TEETH.

By GEORGE W. WELD, M. D., D. D. S.

A consideration of the merits and demerits of the practice of replanting and transplanting the human teeth necessitates a brief review of the subject since the time it was practised by Ambroise Paré,[1] and others in the sixteenth century.

It is a practice which has always excited a great deal of curiosity in as well as outside of the profession. It has a copious history, both ancient and modern, but the practice has been singularly strange and erratic. It has been a plaything and an advertising medium for quacks, as well as a study for conscientious and honest practitioners; and the literature on the subject, although abundant enough, is negative in character and extremely scattered.

It will be the aim of the writer to present as succinctly as possible the opinions of a few eminent authors, which in connection with the histories of a certain number of cases, will, it is to be hoped, serve to bring the subject into more definite relations with the art and science of dentistry, and establish data for future reference.

History of Transplantation.

By transplantation is meant the extraction of a tooth from the alveolar socket of one person and its insertion in the alveolus of another.

In reviewing the early literature of this subject one is struck with the singular fact that the art of transplanting teeth in the early times seemed to have been more generally practised than that of replanting. It is true, however—and should be stated in this connection—that most of the writers on the subject, from near the close of the fifteenth down to the close of the eighteenth century (excepting Hunter), regarded the practice with a great deal of distrust.

Thus we find that Ambroise Paré, who died in 1590, says in a published work: "I have heard it reported by a credible person that he saw a lady of the prime nobility who instead of a rotten tooth she drew made a sound tooth (drawn from one of her waiting-maids at the same time) to be substituted and inserted; which tooth, in the process of time, as it were taking root, grew so firm that she could chew upon it as well

[1] There are good reasons for believing that the practice of replanting and transplanting teeth was in vogue long before Paré's time.

as upon any of the rest. I have this by hearsay." It is evident that Paré placed but little confidence in such reports, for, so far as his own operations in this direction are recorded, it would appear that he confined his efforts entirely to *replanting.* But from his statements on the subject, as well as those of subsequent writers, it is apparant that *transplanting* was in vogue down to near the close of the eighteenth century, and was frequently practised by surgeons who thought but little if anything of *replanting.* This was doubtless due in part to money considerations, for it is altogether likely that a large fee was demanded and obtained for each operation, whereas pecuniary gain did not enter so largely into the operations when confined to the practice of *replanting* teeth.

But although *transplanting* teeth was practised to a considerable extent before Hunter's time, we find that Thomas Berdmore, surgeon dentist, in a work published in 1668 says, in reference to the success of the operation: "If a tooth just extracted and instantly replaced in its socket, which it fits in a manner which no art can equal, fails of taking hold more frequently than it succeeds, and generally is attended with uneasiness and pain, if not with violent inflammation, what shall we say of those who pretend to supply one man with the teeth of another—with teeth which cannot fit properly once in a thousand trials, that must necessarily press on the socket unequally, and therefore occasion inevitable pain and inflammation? The few instances in which they succeed surely are not sufficient to counterbalance the hazard; and were people properly versed in the dentist's art they would certainly prefer the healing of the socket and the use of a well-constructed artificial tooth, or a human tooth with the root filed off and formed to fit the void space exactly. For this will occasion none of the evils that attend the former practice, which is not only precarious, ineffectual, and dangerous in general, but also immoderately expensive; for it is not to be supposed that any young person will sell a handsome tooth, to be torn out of his head, without being extremely well paid for the loss and pain." All this was written and recorded over a hundred years before John Hunter experimented so enthusiastically, although by some at the present day he is considered the father of transplantation and the author of the system.

Why Hunter should have allowed his enthusiasm in this matter to prevail to such an extent as it did can only be explained on the supposition that he at first may have met with encouragement, and then afterward had too much confidence in his own method or ability in performing the operation. For he says in one part of his work that "although this operation is in itself a matter of no difficulty, yet upon the whole it is one of the nicest of all operations, and requires more chirurgical and physiological knowledge than any that comes under the care of the dentist. There are certain cautions necessary to be observed, especially if it be the living tooth which is to be transplanted, because in that case it is meant to retain its life, and we have no great variety of choice. Much likewise depends on the patient: he should apply early, and give the dentist all the time he thinks necessary to get a sufficient number of teeth that appear to be of the proper size." Again, in still another

part of his work he says "that, considering the almost constant variety of the size and shape of the same class of teeth in different people, it would appear almost impossible to find the tooth of one person that should fit with any degree of exactness the socket of another; and this observation is supported—and, indeed, would seem to be proved—by observing the teeth in skeletons. Yet we can actually transplant a tooth from one person to another, Nature assisting the operation: it is done in such a way that she can assist. And the only way in which Nature can assist with respect to either size or shape is by having the fang of the tooth rather smaller than the socket. The socket in this case grows to the tooth. If the fang is too large, it is impossible indeed to insert it at all in that state; however, if the fang should be originally too large, it may be made less; and this seems to answer the purpose as well."

In order to support his statement, Hunter concludes with a very ingenious experiment, by which he attempted to show "that a living tooth when transplanted with some living part of an animal will retain its life, and the vessels of the animal shall communicate with the tooth." "I took," he says, "a sound tooth from a person's head; then made a pretty deep wound with a lancet into the thick part of a cock's comb, and pressed the fang of the tooth into this wound, and fastened it with threads passed through other parts of the comb. The cock was killed some months after, and I injected the head with a very minute injection; the comb was taken off and put into a weak acid, and the tooth being softened by this means, I slit the comb and tooth into two halves, in the long direction of the tooth. I found the vessels of the tooth well injected, and also observed that the external surface of the tooth adhered everywhere to the comb by vessels similar to the union of a tooth with the gums and sockets." As this singular experiment has never been repeated, so far as known, it is impossible to dispute the accuracy of Hunter's observations in this matter, but it is fair, however, to suspect that he was mistaken.

It would appear from a close examination of the tooth[1] which, with the cock's head, has been split into two equal halves, that a partial absorption of the end of the root had already taken place when the cock was killed, and that the tissue of the cock's comb had penetrated far into the pulp-cavity.

That the tooth grew to the cock's comb is a circumstance not at all unlikely; but that the *minute injection* which he referred to (the character of which he does not mention) was capable of permeating the structure of the cementum through the comb seems highly improbable, and it is more than likely that the color and condition of the tooth at the time he examined it was referable to the acid in which the tooth was macerated, rather than to the *minute injection* which, he says, filled the vessels of the tooth. This part of the subject, however, is of little importance. The point upon which particular stress should be laid is the fact that Hunter was finally induced to abandon this practice.

Mr. Bell, editor of Hunter's *Treatise on the Teeth*, says, in this con-

[1] The specimen forms a part of the Hunterian collection.

nection, "that the practice of transplanting originated with Hunter, under whose supervision it was frequently performed. Had the results of all these cases been known to him, it is probable that his recommendation would not have been written. There is not, I believe, a single instance of its perfect success, and there are many in which it has been followed by even fatal results."

In the year 1774, M. Patence, a dentist residing in London, published a work in which he says:

"A case happened to a lady I lately had under my care who had undergone the operation. The tooth transplanted was taken out of the mouth of a person that had the venereal disease, and was bound in with an Indian weed; there presently issued an inflammation in both her upper and lower jawbones; her face swelled to an enormous size, and was in the most curious pain. When she had been in this condition for some time the tooth grew black, but had never fastened, and it was near twenty weeks before she got perfectly well."

In Philadelphia, in the winter of 1785–86, Mr. Lemayeur *transplanted* one hundred and seventy teeth, and not one succeeded, according to Gardette.[1]

The following comments on transplantation are to be found in *A Popular Essay on the Structure, Formation, and Management of the Teeth*, by John Fuller, surgeon dentist, 1810:

"It was once a very popular practice to substitute a complete tooth in the place required. When it succeeded the transplanted tooth in general remained only a few years; from such circumstances it gradually sunk into disuse, and is now, we hope, consigned to its merited oblivion."

In the *Am. Lib. Dent. Science*, vols. iii. and iv. p. 107 (Jobson), we find the following stricture on the practice:

"This operation, the most revolting and unjustifiable of all that have ever been performed on the teeth or any other part of the body, is now completely exploded from the practice of the modern dentist. The argument which Hunter uses in its commendation, and the directions he gives for performing the operation are so absurd and inconsistent that, were it not well known to have been a favorite practice of his, posterity might well believe that this part of his work was surreptitious. . . . . It is surprising, indeed, that such an idea should ever have emanated from so profound a physiologist as Hunter; and it proves how much a man's better judgment may occasionally be biassed when in the pursuit of a favorite object."

A fatal case of transplantation is related in the *Medical Transactions of the College of Physicians of London*, vol. iii. pp. 325–338:[2]

"An unmarried lady," says the writer, "twenty-one years of age, had one of the incisor teeth of her upper jaw affected with caries: it was extracted, and its place very dexterously supplied by a like tooth from another young woman, who upon a most rigid examination for the purpose appeared to be in excellent health. The implanted tooth very rapidly

[1] *Am. Journ.*, 1850, p. 65.

[2] See also chapter on the causes of the diseases of the jaws in a published work by Leonard Koecker, surgeon dentist, Philadelphia, 1847.

took a firm hold, and soon bade fair to be of great service and ornament. In about a month, however, the mouth became painful, the gums inflamed, discolored, and ulcerated. The ulceration spread very fast; the gums of the upper jaw were destroyed and the sockets left bare. Before the end of another month the ulceration stretched outwardly over the upper lip and nose, and inwardly to the cheeks and throat, which were corroded by large, deep, and fetid sores. The gums soon became carious, several of the teeth successively dropped out, and these at length were followed by the implanted tooth, which had hitherto remained firm in its place. About this time also blotches appeared on the face, neck, and various parts of the body, many of which became painful and extensive ulcers: a considerable degree of fever, apparently hectic, was excited; a copious and fetid discharge flowed from the mouth and throat and impeded sleep, and the soreness of the parts which performed deglutition prevented sufficient nourishment from being swallowed. Medicines exhibited in every possible form that science matured by experience could suggest failed altogether of removing or even mitigating the unhappy sufferer's distresses; the virulent taint or putrescent tendency established in the system, though occasionally driven back, as often rallied, and ultimately prevailed; the patient fell a victim to it in the greatest anguish and misery. The patient from whom the tooth had been taken had all along continued to enjoy the most perfect health; she was frequently and scrutinously examined, without a single trace of disease being discovered existing in her person or constitution."

Dr. Joseph Fox, a celebrated dentist who wrote upon this subject in 1814, says:

"The ill-success and unfortunate consequences that have sometimes occurred have caused the practice to be abandoned for many years past. The other methods of supplying the loss of teeth are so unexceptionable and invariably successful that we have no reason to regret the failure of the method of transplanting. I might have observed that this operation involved in it a defect of moral principle, as one person is injured and disfigured in order to contribute to the luxury or convenience of another."

Dr. R. Wooffendale, a dentist who resided in London in 1778, in a published work says that "the *transplantation* of *teeth* is a very desirable operation when it succeeds; but it may not be improper to observe that the success in a great measure depends on chance."

But, notwithstanding the fact that the art of transplanting teeth has been looked upon with distrust and condemned by most authors during the past three hundred years, it is not an uncommon thing at the present day to read published articles favorable to and recommending this system. It is no more than fair to remark, however, that these articles are generally written from an observation of a single case, which for a short period of time (or for a long period of time under favorable conditions) has proved uncommonly successful. Such an article was recently published by Dr. Thomas of Detroit,[1] in which the writer records the following case:

"Last winter N. C——, a gentleman about thirty-five years of age, was under my care for the treatment of his teeth. . . . The right superior

[1] *Dental Register*, vol. xxxii. p. 281.

cuspidate had been filled some years previously; filling had been leaking, and, having been neglected, the crown had wasted away till nothing of the tooth remained when he came under my care save a large hollow root. . . . . On the last day of February I extracted the root by means of the screw, and took a corresponding sound tooth that I had removed from the mouth of a lady about the same age just four weeks previously. In preparing for artificial teeth (it being the only sound tooth in the upper jaw, it was thought best to remove it), I opened into the canal and pulp-chamber from the apex of the root only; cut the end off one-eighth of an inch, it being that much too long; reduced the size somewhat in the centre of the root, it being a trifle larger than the root extracted; filled and placed it in position.

"The occlusion, shape, and color were perfect, so much so that several dentists who saw the case within a few weeks after the operation, and being told it was one of the superior six front teeth, and requested to point it out, were unable to do so. . . . . It has now been three months since the operation, and the patient informs me that he has known no difference between it and any of his other teeth since the first four weeks."

The following case is recorded by Dr. G. F. Waters of Boston:

"On March 23, 1874, I extracted a root of the first right superior bicuspid, and replaced in the socket a tooth extracted in a *case of regulation* for a girl æt. fifteen years, on January 12, 1874. This tooth was cleaned and all soft tissue removed at the time of extraction; and after the dental canal had been filled with gold-foil it was bottled in a 6-per-cent. solution of carbolic acid. It was bifurcated at both ends; both roots were filled and capped with gold. An imperfection in the bifurcation of the crown gave entrance to the pulp-chamber, and enabled me to make all of the fillings continuous. The root of the tooth was bathed in a solution of aromatic sulphuric acid (one-fourth officinal strength) for a few moments, and, after having been washed with water and replaced in the socket, it was crowded into place by the under teeth. It proved to be too long, was extracted, and the inner cusp ground off to make the occlusion right. The extraction and replacement had to be repeated two or three times. When the length of the tooth was just right I tied it to the adjoining teeth, and at the end of a week it was safely anchored. It has given no sensation since."

Among modern authorities, one of the pronounced advocates of transplantation is Dr. Coleman, whose remarks we here reproduce:[1]

"The chief arguments employed against the operation were, as we pointed out some years ago,[2] the three following—viz. 1. Liability to failure; 2. Chance of inoculation of disease; 3. The moral objection.

"1. *Liability to Failure.*—This is considerable, and may arise from the so-called scion-tooth not being, from its size, form of fang, or injury occurring to it in its removal, etc., adaptable to the socket of the tooth which it is intended to supplant. Also, when the above-mentioned conditions are not unfavorable it often happens that the scion-tooth is implanted in an alveolus more or less diseased from the long existence of a necrosed tooth. Pain and tenderness are for some days a common sequence to the operation, and even under favorable circumstances are often severe; and, the tooth

[1] See *Manual of Dental Surgery and Pathology*, by Alfred Coleman, L. R. C. P., etc., edited by Thomas C. Stellwagen, A. M., M. D., D. D. S., pp. 349–350.

[2] "On the Transplantation of Teeth," by Alfred Coleman, *St. Bartholomew's Hospital Reports*, vol. xiv. p. 101.

being very loose, the patient is tempted to obtain relief by removing it. The method also commonly employed of attempting to secure the transplanted tooth to adjacent ones by means of ligature was, as we think we shall be able to show, another very probable cause of failure.

"2. *Chance of Inoculation of Disease.*—This we believe to have been much more imaginary than real, although it cannot be denied that there might be a chance of transferring, with a tooth removed from a person at a certain stage of the disease, such affections as syphilis, smallpox, scarlatina, measles, etc.; and the same objection would apply in an equal degree to skin-grafting from one person to another, as well as to several other surgical proceedings. We are inclined, however, to believe that this argument was employed rather to deter and dissuade persons from undergoing an operation so properly discontinued on the ground of—

"3. *The Moral Objection.*—That the poor and generally degraded should have been induced by a pecuniary temptation to part with organs as essential, or probably even more essential, to their well-being than to the wealthy coveters who could purchase them, came, and rightly so, to be regarded as an injustice and a wrong. A much greater skill and success in saving defective teeth, and in supplying artificially their place when lost, no doubt also, to a very great extent, diverted attention from the operation of transplantation.

"The success that attended our experiments in replantation, though not very encouraging, determined us nevertheless to attempt that of transplantation, but under conditions wholly free from the moral objection above stated.

"It has been pointed out in previous pages (see chapter iv.) that amongst civilized nations the maxillæ of the present generation are of smaller size than they were in people who lived some centuries ago, whilst the teeth, if they have diminished in size, have not done so in the same proportion, and thus occur crowding and irregularity in position of the latter. The dental surgeon is often called upon to correct this by the removal of sound teeth; and that these young and healthy teeth should be cast away as useless, whilst there were so many for whom the operation of transplantation, if successfully performed, would be the greatest boon, appeared to us a sad misfortune.

"We have, therefore, from time to time during the last six years performed the operation of transplanting teeth from the mouths of those who had to part with them through overcrowding to the mouths of those from whom they were removed on account of disease, and with a much greater proportionate success than in the operation of replantation for the cure of periodontitis. We have performed it on at least twelve occasions, and we believe with only two failures, both resulting from the tooth not being adaptable to its new habitation. Besides these cases, it has been performed by others under our observation some fifteen times—not, we believe, with quite the same success, as the cases were probably not so carefully selected. Our first case, that of a medical student in 1875, for whom a right lateral incisor was thus supplied, was, when last heard of, about a year ago, perfectly satisfactory. In two of the cases we transplanted misplaced laterals to alveoli on the opposite side in the same patients, and were successful. In another case, that of a youth aged sixteen, two upper laterals were transplanted from another subject with perfect success.

"The operation, which we always conducted under an anæsthetic, was thus performed: The individual to receive was operated upon first, every

care being taken in the removal of the tooth or root to injure the alveolus as little as possible; the mouth was washed out with tepid water until bleeding had nearly ceased. The patient to contribute was then operated on, and, his tooth being also carefully extracted, it was carried directly to the former and firmly pressed into the vacant alveolus, after clearing out the same, first with cotton-wool and then with the syringe, the finger and thumb only being employed. In no instance was any ligature employed, this being in our opinion more likely to prove mischievous than beneficial, and for the following reason: The tooth, however firmly pressed into the socket, soon becomes slightly raised from it by effusion into the latter, which causes it also to be more or less loose. Now, this effusion has no doubt much to do with the future union of the tooth and alveolus through the medium of the alveolo-dental membrane; and to prevent this effusion, as must be the case to a great extent when the tooth is firmly tied into the socket, is to interfere with the process of attachment. Moreover, we are strongly inclined to attribute to this procedure those untoward results—viz. severe inflammation, abscess, necrosis of alveoli, etc.—which have been spoken of by former writers as not unfrequently following this operation, but which we have never met with. After having implanted the tooth we have simply directed the patient to carefully avoid masticating upon or touching it with the opposing ones for some days, and to employ soothing fomentations to relieve any tenderness. There could be no objection to construct, previously to the operation, a plate that would protect the tooth from any violence or pressure.

"In some cases a week only has sufficed to allow the tooth to become moderately firm, free from tenderness, and even capable of bearing a certain amount of pressure; but a fortnight has more commonly been required. A point of no small importance is to select for transplantation, if possible, teeth the fangs of which are rather less in dimensions than those for which they are to be substituted. When transplanted they may not appear so firm as larger ones, but in the end they become so. In our practice lateral incisors inserted into the alveoli of centrals and cuspidati have turned out very successful. In speaking of the transplantation of teeth—which under the conditions spoken of may, we consider, from our experience of it, be recommended as a useful and perfectly legitimate operation—we may repeat what we have elsewhere written: 'I am in hopes that, having called attention to the operation and its merits, it may be the means of conferring much benefit, especially upon a class whose pecuniary circumstances prevent them from attaining comforts which their more affluent neighbors can well afford. I cannot but believe that with our dental departments and dental hospitals, at which so many thousands of young and healthy teeth are annually sacrificed, these might be turned to profitable account, and by selection of suitable cases out of large numbers the operation of transplantation might be again regarded as legitimate and useful.'"

In concluding the subject of transplanting I take the liberty to quote the closing part of an article[1] recently published, in which the author says:

"The attempts to revive the exploded system at the present day are more unjustifiable, as great advancement has been made in the profession within the past fifty years, and greater resources have been brought within reach

[1] "Transplantation and Replantation of the Teeth," by William Taft, published in the *Dental Register*, vol. xxx. p. 467.

by the rapid progress in other arts and sciences. It would seem unnecessary to enter into further discussion respecting the inhumanity or impropriety of inflicting pain and injury on one individual in order to give another the chance of a very uncertain advantage. Nor is the evil confined to a mere failure of the operation or the troubles in the organs for which the remedies are designed. The danger of inoculation in the process of transplanting becomes the means of transferring the diseases of one individual into another, and even the animal matter of the transplanted tooth may, under certain circumstances, prove very injurious by undergoing putrefactive change. In view of all these evils, uncertainties, and dangers we must discountenance the revival of a discarded system which could only have found favor in past times, when art, science, and the morals of society were at a very low ebb, and which must be strongly condemned by the free and enlightened spirit of the present age."

History of Replantation.

By replantation is meant the extraction of a tooth and its replacement in the alveolar socket of the same patient.

There seems to be but little in the history of *replanting* teeth to justify the hope that this practice will ever prevail to any great extent in the future. Most of the ancient writers on this subject, whilst looking upon the practice with more favor than that of *transplanting*, nevertheless expressed considerable doubt as to its probable success and practicability. Thus we find that Thomas Berdmore says in this connection: "The surgeon's art has taught that a tooth which has been partially or totally forced out of its socket may be restored to its former situation and firmness, and may serve for use and ornament to the latest period of life." Yet in another part of his work he says that "after all that has been said on this subject I think it necessary to add, for the sake of undissembled truth, the imputation of countenancing the impositions that occur every day, that the success on all these occasions, however sufficient to justify the future trial and practice of honest and judicious people, is by no means equal to the extravagant assertions and promises of certain advertising impostors. In the most favorable circumstances it is more than an equal chance that a tooth once extracted or beat out will fasten again."

The practice of replanting teeth from the time of Paré down to the present day may be compared to a protracted case of intermittent fever —a practice which has appeared to entirely subside at certain intervals, only to break out again with renewed force and ardor. And it is to be observed that with each revival of the subject the party or parties endeavoring to distinguish himself or themselves in this direction think either that they have some superior method of treatment or that their deeper researches and superior knowledge of the subject enable them to perform the operation when others would fail. In this connection it may be stated that the facts coming to the knowledge of such parties upon which they presume to base their success are those generally deduced from a single case of a reunion of a dislocated tooth with the alveolus (when replaced after extraction), without having especial reference to the durability of the operation. Such was the case in the time

of Paré and Berdmore, and it has been so during the past century, and has extended up to the present day.

It is possible, however—and, in fact, not at all improbable—that a tooth when replanted under favorable conditions of environment, age, constitution, and health will remain firmly attached to the jaw for many years and do good service. I have known instances of this kind, and have heard of many others. Dr. G. R. Thomas of Detroit has replanted (including a few cases of transplantation) nearly five hundred teeth, many of which, he observes, are doing good service. But he also observes, in another part of a letter addressed to me, that "my enthusiasm like your own, is wellnigh paralyzed so far as the permanent beneficial results of this kind of treatment are concerned."

The following cases in point (recorded by Dr. G. F. Waters, a practical dentist of Boston) will show the successes which are sometimes associated with the operation:

CASE I.—"In the year 1856 it chanced that a second bicuspid tooth was crowded out whilst I was extracting the first permanent molar for a boy of seventeen years of age. The tooth was perfectly sound, and fell to the floor. I picked it up, rinsed off the blood, and replaced it in the socket before it was missed by the owner. I told him what had occurred, and charged him to favor the tooth for a few days, not doubting that in that time it would be all right. I have not heard from this case since, and as I lived in the town where the boy resided for a period of eight years after the operation, I suppose it to be all right."

CASE II.—"In 1868 a man called at my office with a badly-abscessed left inferior third molar that had been filled with gold a week before on the buccal surface (the pulp probably having been devitalized by arsenic) and requested its extraction; which being done, he so grieved over its loss that I said, 'Let me return it.' He was at first fearful that it would give him a worse pain. But I assured him that it would not cause pain to replace it, although the tooth might be sore for a few days. I then removed a large sac of pus from the apex, replaced the tooth, and the man went away gratified."

CASE III.—"On Nov. 30, 1867, a man called at my office to have a tooth extracted. He was a carpenter by trade, and exposed to all kinds of New England weather. He had suffered much from this tooth, which, although apparently sound, was of a darker color than his other teeth, they also being yellow and dirty, whilst the gums were red and swollen. It was a third inferior molar (the first and second missing). I assured him that the tooth could be saved by proper treatment. But he was faithless, and declined everything but extraction. The moment the tooth was out he grasped the forceps to get the 'first look at the tooth.' He evidently expected to find it decayed, for he at once said, 'I would not have had it out for fifty dollars if I had not supposed it to be decayed.'—'But I told you it was not.'—'Yes, I know, but I thought I knew better than you did.'—'I can put it back.'—'Can you, though?' exclaimed the man. I did so, and, as I had previously done up to this time, without other treatment than washing the tooth and socket with warm water. It was again extracted in March, 1871, having been in use for over three years."

CASE IV.—"The following remarkable case of replantation of the four superior central incisors was reported to the Massachusetts Dental Society

by the late Dr. N. C. Keep; the case occurred at the time he was a student of dentistry with Dr. Reynolds: The patient was a young girl æt. fourteen, who while coasting one warm afternoon in March was thrown from her sled, and struck with such force upon her face that her four upper front teeth were completely luxated and her lip badly cut. The girl went to her home, leaving the teeth where the accident occurred. The girl's mother was in Boston, seven miles away. On returning in the evening at seven o'clock, and learning the nature of the accident which had befallen her daughter, a search was instituted for the missing teeth, which by the aid of a lantern were found at the coasting-place. In company with her mother the girl was then driven to the office of Dr. Reynolds, arriving there at a little past ten o'clock on the same evening. The four teeth were examined by the doctor, and, after having been thoroughly washed, were returned to their sockets, the teeth being supported by a splint improvised from an old barrel-stave. Dr. Keep saw this case when the girl had grown to be a woman of forty-four, at which time all these teeth were in place, and, with one exception, discolored. Abscesses had formed over three of them which discharged for a long time, but finally healed."

Case V.—Dr. Keep relates that on Nov. 22, 1870, he extracted his own right superior lateral incisor, badly abscessed and decayed on both proximal surfaces. He cleansed and filled the tooth, including the pulp-canal, and on the following day had it replaced by Dr. Cogswell of Boston. A slight discharge occurred, which, however, soon passed away, and the tooth was worn with great comfort for a period of four years, at the end of which time the crown was accidentally fractured in eating. The root remained in position two years longer, and was then extracted.

Case VI.—This case is also reported by Dr. Keep: "On March 9, 1875, I extracted my left superior lateral incisor, the pulp of which was exposed, and after filling the root and crown with gold replaced it in the socket. I have a memorandum that on the 12th of April this tooth felt natural, sound, and in a good condition. On the 17th of May, the month following, I had a severe pain in the left superior central incisor, and called on Dr. C. H. Osgood to get him to extract it for me. But instead he took out the *lateral incisor*, which I had replanted, leaving the *central* and the pain still remaining in my head. On examination, I found a piece of the alveolus firmly attached to the root. I also found numerous small pits, from absorption of the cementum; and on the side next to the central incisor was a shallow groove similar in appearance to the grooves in the bones in which arteries run."

It is a difficult matter in this case to account for the piece of alveolus which the doctor says was firmly attached to the root, and especially when we consider that the surrounding conditions were conducive to atrophy, or absorption rather than hypertrophy or normal nutritive supply, as indicated by the "numerous small pits" which the doctor says he observed on the cementum.

Case VII.—"Tooth replanted Mar. 22, 1871, in the mouth of an adult. Inflammation supervened, and tooth was extracted April 1st. On examination I found the root bathed in pus, but the buccal, lingual, and anterior surfaces appeared to be covered with a soft connective tissue. Yet when the tooth was replaced in position all of the soft tissue was thoroughly removed."[1]

[1] In a *Practical Essay on the Human Teeth*, by Paul Eurialius Julion, London, 1781,

The following case of replantation[1] is taken from Johnston's *Dental Miscellany*, vol. viii. p. 339:

"A few months since a gentleman of nervous temperament and about twenty-seven years of age called to have a superior central incisor treated and filled. On examination there was found a fistulous opening through the gum to the apex of the root, and on inquiry it transpired that there had been periodical discharges through the gum for several years. After unsuccessful treatment through the root—and my patient would not submit to an incision through from the outside—I decided to extract, fill, and replace the tooth—*i. e.* after he made the proposition. I first made known to him the probable success and the possibility of a failure. The gentleman did not want to lose the tooth, and, having read of several successful cases of reimplantation, wished me to perform the operation.

"After having the tooth prepared for its alveolar socket, which took but twenty minutes, I syringed the cavity out with a weak solution of carbolic acid, placed the tooth in it, and fastened it with ligatures to the adjoining teeth. It then seemed almost as firm as any of his other teeth. I also cut off about two lines of the end of the root. My patient called every other day for three weeks, but, the tooth not causing him any pain or trouble, the ligatures were not cut until the three weeks were up, when the tooth spontaneously dropped out. I have replanted ten teeth; four were failures, while six of them, *so far as I know*, are doing well."

E. Chenery, M. D., in the *Dental Cosmos*, vol. xx. p. 350, relates his experience in replanting teeth, as follows:

"I had a left lower bicuspid forced out by the root of the molar next to it when it was being extracted. The dentist replaced the tooth, and after five months it ceased to be tender and was firm and useful. Five and a half years later, without known cause, it began to ache and was tender. Nothing seemed to have any effect to relieve it, and, after three days' torment, I submitted to its removal. I did not suppose that this accession of inflammation in my case had anything to do with its previous removal. I was disposed to regard it as a mere coincidence."

The *manner of operation* and *treatment* in connection with the *practical aspects of replanting teeth*, will now be considered, and, for convenience, arranged under two heads—viz.:

(1) Cases of necessity;

(2) Cases of choice.

Cases of necessity are those in which teeth are replanted after dislocation resulting from severe blows or falls upon the face, or after a wrong tooth has been extracted. Such cases, although not uncommon in adults, are chiefly confined to children. Of this class the dental practitioner will generally observe two different conditions.

The first condition is where a tooth is luxated, so far as the alveolar attachments are concerned, but is prevented from falling out by a nonruptured pulp: this sometimes happens with children, in whose teeth

the author states that "when there is a cavity formed on the side of a tooth by caries or decay, which cannot be filled up on account of its being inaccessible while the tooth remains in the head, it is advisable to take it out and stop up the cavity; when this is done and the tooth properly replaced in its socket, it will, with due care, become as firm and serviceable as ever, providing the patient be then in health."

[1] By Dr. G. O. Shafer, Champaign, Ill.

the apical foramen is relatively large. Even where the pulp is ruptured the tooth may still be suspended by, and retain a slight vascular attachment through, a shred of the peridental membrane or be prevented from dropping out by an adhesion of the gum-tissues upon the side opposite to that to which the dislocating force was applied. When a luxated tooth is found to still have points of adhesion, it is very essential that their true nature should be accurately determined, and when it is found that the tooth is hanging by a mere shred of pericementum or gum-tissue, it is better, as a rule, to completely detach it and treat it as hereafter to be described for that class of cases.

In the above class of cases the services of the dentist are frequently not called into requisition until the tooth has been replaced in the socket by the child's parents or by those present at the time of the accident.

The other condition referred to relates to a total luxation, or when a tooth is not only separated from the process, but dissociated from all vascular connection by rupture of the pulp-attachments. It frequently happens in such cases that the tooth falls to the ground, is picked up, and, after having been washed, is replaced in the socket. In both of the above conditions the result, so far as immediate union is concerned, is about the same, but the *treatment*, which will be considered on another page, will in each case be somewhat different.

By the phrase "cases of *choice*" is meant cases in which teeth are extracted and immediately replaced in the alveolar processes. Such a course has been pursued for the purpose of curing an alveolar abscess. Indeed, certain practitioners have affirmed it to be the proper method of treatment, especially with incisor and bicuspid teeth where the abscess has been long continued and persistent. The practice too has been resorted to for even more questionable reasons, such as to give relief from severe toothache or neuralgia or for the purpose of filling sensitive carious cavities, and also for convenience in adjusting artificial crowns.

In those cases where the pulp has not been ruptured the first and principal thing to do, after the tooth has been replaced in the socket, is to guard against any interference with the process of healing, such as an undue oscillation or the constant friction and jar sometimes caused by an occluding tooth. This is best accomplished by passing a silk ligature around the tooth, which in turn is securely fastened to the adjacent teeth. The patient is then advised to abstain from biting upon any hard substances, and warned against undue exposure to wet and cold. Aside from these precautions, but little if any other treatment is required. It is very seldom that the operation annoys the patient—to such an extent, at least, as to prevent him from attending to his daily duties. The tooth usually becomes firmly attached to the alveolar socket in the course of three or four weeks.

In those cases where there has been a rupture of the pulp and a complete luxation, in addition to what has already been mentioned it is necessary to wash the tooth in a little warm water, remove with a small file any roughness or any sharp points near the apical foramen, and then by the aid of a syringe and tepid water wash out any coagulated blood that may be found in the alveolar socket.

Some practitioners have been in the habit of washing out the socket and immersing the tooth in a solution of carbolic acid. There is no objection to this plan, provided the solution be not too strong, not exceeding 4 or 5 per cent. But as antiseptic measures are hardly required in such operations, there is no particular reason for commending them.

The essential point in the operation is to see that the root of the tooth is perfectly clean and that it has no rough surfaces or sharp points likely to irritate the surrounding parts and thus increase the inflammatory action.

In case inflammation supervenes to an extent likely to endanger the success of the operation, warm applications may be applied to the external parts of the face, the patient cautioned against any exposure, and the usual methods for combating inflammation of the peridental membrane resorted to.

One other very important point in connection with the operation relates to the extirpation of the *pulp* contained within the tooth. Some practitioners have been in the habit of removing the pulp before replacing the tooth in the socket, they claiming that inasmuch as the ruptured vessels and nerve-fibres never reunite, there is no advantage in retaining it, but, on the contrary, a good reason for its removal, as its presence tends to retard the process of healing and the reattachment of the tooth. It is, on the other hand, claimed by others that there is a possibility of saving the pulp alive—in other words, that a reunion of the divided pulp-tissues may take place after the tooth has been returned to the socket.

Dr. William H. Atkinson believes that he has, in the mouths of patients, four or five teeth which have been extracted and returned to their sockets, and which still have living pulps in them.[1]

Some six years ago I had occasion to refill two superior incisor teeth, both of which had, over forty years before, been completely luxated and suspended by their respective pulps. I found on excavating these teeth that neither of them was sensitive. In one the pulp-chamber and canal were found to have been obliterated by a process of calcification, no trace of pulp-tissue remaining. The lady assured me that the teeth had never abscessed nor given her any pain or annoyance since the day of the accident and the time they were replaced in their sockets by her father. From the patient's statements I concluded that the pulps in both of these teeth had remained vital for a certain period of time, the changes observed being the result of nutritive disturbances. Except a very slight opacity in one of the teeth, external examination gave no indication either of the absence of the pulp or of the condition of things as above mentioned.

In considering the possibility of a reunion of a ruptured pulp it is well to keep in mind the peculiarities of nerve-tissues, and especially the readiness with which the two ends of a divided nerve will sometimes reunite. Thus it has been observed in the treatment of severe cases of facial neuralgia where, in order to obtain relief from pain, a nerve-branch has been divided, that in a subsequent operation for

[1] See *Dental Cosmos*, vol. xix. p. 305.

the same purpose the two ends of the divided nerve have been found reunited.

The suturing of the two ends of a divided nerve to remedy paralysis is not an uncommon occurrence in surgical practice; and the fortunate fact in connection with such an operation is that in a great majority of cases, if the operation be carefully performed, a complete union and sometimes a complete restoration of function take place. It would seem, therefore, not impossible that a union may take place between the two ends of one of the terminal branches of the fifth pair of nerves under the conditions as above mentioned. But I am of the opinion that these conditions are very unfavorable to such a union, and that its occurrence is an exception to the general rule. This conclusion is based upon information on this point received from others, as well as upon my own experience, death, resulting in suppuration and abscess, having invariably followed the return of the tooth to the socket in every case which has come under my observation in which the pulp-connections had been severed.

It has, therefore, been my custom, either to remove the pulp and fill the root before replacing the tooth in the alveolus, or to simply drill a small hole into the pulp-chamber through the lingual surface of the crown, thus preventing the accumulation in the tooth of fetid gases, the irritating properties of which in all cases militate greatly against a speedy reattachment. After the tooth has become firm in the socket the pulp-cavity can be treated antiseptically and closed with a suitable stopping.

Elongation.—To prevent the relative elongation of replanted teeth some practitioners advocate the cutting off of the end of the root from a sixteenth to an eighth of an inch. So far as my experience goes, this procedure in the great majority of cases is not necessary; for if the socket be thoroughly freed from coagulated blood and the tooth be properly replaced therein, the relative elongation,[1] always present for a few days, will, as a rule, entirely disappear by the time it has become firmly attached to the alveolus.

On this point Thomas Berdmore, whose name has already been mentioned in connection with this subject, says that "in the case of a grown person when the tooth is totally beat out, or when a surgeon is not at hand to reduce in the very instant the swelling of the vessels, and extravasated blood prevents its being replaced as deep as before, and as a prominence above the rest of the teeth would expose it to future injury and pain, it is found necessary to cut off a little piece of the root, to smooth it well, to fill the hole in which the nerve formerly lodged with lead or gold, then to reduce it carefully, and to fasten it to the neighboring teeth."

It is claimed that the cutting off of the end of a root in no wise impairs the process of restoration, and that it guards against the possibility of tetanus being caused by the end of the root impinging upon and irritating the dental nerve. The possible danger of tetanus resulting from the operation of replanting teeth has been recognized by a number of

[1] It may be observed that a tooth which does not meet with another in occlusion will be gradually displaced from its socket, producing an elongation which is relative, not absolute.

observers, but the connection between the two has never been clearly traced or definitely settled.

There is one case on record, however, in which this relationship is supposed to have existed. The late Professor George T. Barker of Philadelphia replanted a tooth for a patient in whom tetanus followed so closely upon the operation that there was but little room for doubt that the replantation was the exciting cause.

It is a well-known fact that tetanus is quite as apt to follow slight as severe operations, a trifling injury sometimes inducing it.

Our knowledge concerning the pathology of this disease is limited, but the symptoms which characterize it are doubtless referable to an abnormal influence upon the nervous centres which control the action of the voluntary muscles. A writer[1] on this subject says "that there is much in the phenomena presented by some instances of traumatic tetanus to lead us to think that the violent contraction of the muscles in this disease is due to irritation set up in the peripheral distribution of a nerve, and that this hyperaction, once established, is conveyed along the nerve to the spinal cord, exciting by reflex action the muscles near the injured nerve to a state of spasm."

It is possible, then, all things considered, that the sharp end of a replanted tooth, impinging on one of the branches of the superior or inferior dental nerve, might in some cases induce tetanus. But if this hypothesis be correct—and past experience warrants us in drawing such a conclusion—the cutting off of the end of the root from a sixteenth to a fourth of an inch, as recommended by some practitioners, would not appear to be necessary, as simply rounding and smoothing the root end would sufficiently prevent mechanical irritation.

The Rationale of the Process of Repair.

The bond of union which may be set up between the cementum of an extracted and replaced tooth and the walls of its alveolus is a subject which has given rise to much speculation. Some are of the opinion that a full, *vital* connection between the tissues in question may be re-established; others hold that the tooth is retained by an osseous deposit upon the external surface of its root; while others affirm that the retention of either a replanted or transplanted tooth is simply mechanical and due to *a contraction of the alveolar walls upon the root.*

The theory that the full normal vascular and nervous connections of a replanted tooth may be re-established has but little to sustain it; and while it cannot be said that its occurrence is and must always be an absolute impossibility, its extreme improbability must be recognized by all. The doctrine is in the main based upon a few isolated experiments by observers who, while unquestionably honest, might easily have been mistaken.

Those of Hunter have already been alluded to. Mitscherlich, in his classic treatise on the subject,[2] refers to an experiment by Wiesemann, who "replanted in a dog a tooth a few minutes after its extraction, and

[1] Quain's *Dictionary of Medicine*, p. 1610.

[2] "Physiological Expositions on the Process of Repair," *Langenbuch's Archiv für Chirurgie*, vol. iv. pp. 405–417, Berlin, 1863.

killed the dog seven weeks later. He macerated the lower jaw, denuded of the soft parts, for fourteen hours in a solution of muriatic acid, and he found the tooth, especially its front part, closely united with the gum, which was filled with many vessels. A vessel not at all small, filled with injection mass, had penetrated into the root of the implanted tooth and disposed itself soon afterward into two parts. This preparation can be found in the museum at Bonn."

Of an experiment by himself Mitscherlich says:

"I replanted in a one-year old dog the second lower molar tooth, extracted from the left half of the lower jaw, killed the dog after six weeks, and injected the head, which I had cut off through both the carotid arteries. This tooth differed from the corresponding one on the other side only in a slight movability. The color and lustre of the tooth were tolerably normal, the gum being connected uniformly and closely to it all around. Upon being sawed through, the pulp showed no change in any respect; it filled out the cavity of the tooth completely, and consisted of the normal elements. The injection mass had only imperfectly filled the vessels, inasmuch as only here and there quantities thereof were found. The periosteum lay everywhere uniformly and normally, not only close to the root, but also to the alveolus. At no point was any ulceration to be observed. Accordingly, we cannot doubt but that in some cases the actual union between a re- or transplanted tooth and the alveolus can be accomplished. We cannot, however, insist that this union must necessarily take place, inasmuch as a mechanical union, as we shall see later on, can also likewise hold the tooth firmly in position."

Hunter held "that the socket grew to the tooth," and that "the success of the operation was founded on the fact of a disposition in all living substances to unite when brought into contact with another, although they are of a different structure, and even the circulation is only carried on in one of them." This view, although magnificent as a generalization and largely confirmed by physiological researches and by many of the brilliant restorative operations in modern surgery, has not been sustained by the mass of experimentations with the teeth.

The fact that neither Wiesemann nor Mitscherlich had any great familiarity with the minute anatomy of the parts involved, and, indeed, entertained erroneous notions concerning it, taken in connection with the well-known mechanical difficulties of making reliable microscopic sections of the teeth and their investments—difficulties which even now have been only partially overcome—must go far toward invalidating the conclusions based upon these experiments.[1]

The theory that the replanted tooth may be retained by an osseous deposit upon the external surface of the root is equally erroneous, although this too has had its upholders. Mitscherlich[2] describes such a deposit as having been formed in the following experiment:

"After I had sawed across the crown of the upper incisor taken from a dog's skull, and drilled transversely a fine hole under the saw-cut, this tooth

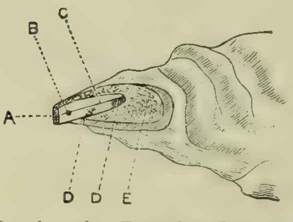
[1] The action of muriatic acid would so destroy the tissues as to utterly preclude any microscopical, or even macroscopical examination, of the soft tissues with any degree of certainty.

[2] *Op. cit.*

was inserted in the place of the correspondingly extracted one, and firmly fastened by means of a silver wire which extended through a hole drilled in the alveolus of the upper jaw. The dog was fed exclusively on soft food, care being taken to prevent it from biting on the new tooth by purposely inflicting pain on the part in the lower jaw opposite this tooth. Six weeks later the dog was killed after having been fed (daily for the last few days) with kali picronitricum grs. iij, three times a day; the carotids were instantly injected. I found the muscles as well as the gums colored yellowish, yet there appeared no change of color whatever either in the inserted tooth or in the normal teeth. The silver wire was loose, and no longer firmly supported the tooth, for on being removed the tooth stood perfectly firm in the cavity and could not be moved in the least by the fingers. The gum was closely adherent to both the tooth and alveolar process, and presented no change whatever. With a fine saw the tooth was cut lengthwise with the upper jaw, so that the pulp-cavity was fully exposed throughout its whole length. The cavity was filled with a little detritus, but of pulp nothing was to be seen, and none of the injection mass penetrated the cavity. The tooth was very closely attached to the surrounding parts, and there was nowhere any ulceration to be seen. There were seen only a few remnants of the periosteum in isolated places. At the posterior surface of the tooth two small cavities were visible, of which the longer was situated near the apex of the root and reached to the pulp-cavity. The walls were filled with a softer mass, and their surrounding walls appeared roundish.

"By an examination with the microscope this was confirmed, inasmuch as traces of the periosteum were found only in a few places, and particularly on the anterior surface of the tooth. In places where the periosteum was absent the tooth had grown out of its own substance, and the resorption there had taken place in such a manner that many little spherical segments appeared on the cut similar to the fungus growths which are found on the ivory pegs inserted in bones which for a long time were preserved by them. In both the above-named cavities the resorption had advanced farther and farther, and had finally assumed the above-mentioned size. The cement-substance was visible only in isolated places; its main part had been absorbed. In the cavities of the tooth-substance there was found imbedded a mass of bone-substance which adhered without any medium substance to the walls of the cavities, and thereby held the tooth exceedingly firm. The bone-substance which adhered to the alveolar processes was liberally filled with blood-vessels, which sometimes were in close relation to the tooth-substance. This was developed in most places so perfectly that the process had to be considered completely finished, in consequence of which a later exfoliation of the tooth could not be assumed. The dentine itself showed nothing anomalous.

Fig. 238.



Cut through a Transplanted Incisor (and contiguous parts) reattached to the upper jaw of a dog, six weeks after insertion (magnified three-fold): A, surface of cut through the crown; B, hole bored for silver wire; C, root-canal; D, reabsorbed places in dentine; E, alveolar process of upper jaw.

"How this process was brought about seems to me not to be made entirely clear by this single case; the various steps leading to the consummation of the process are wanting. Still, I believe it could have been accomplished by no other means than those which I have mentioned above. The periosteum seems to bring about, by reason of the continual pressure,

a partial absorption of the tooth; and as there is formed a bone-mass out of the soft substances, the firm retention of the tooth is effected in this extraordinary manner, as we have observed in most of the experiments. The details of this case explain the reason for the failure of several experiments which I have made with the reattachment of porcelain teeth. In the two cases in which I have attempted to plant porcelain teeth in men the teeth were roughly cut on the root and provided with some continuous cross-cuts in order to offer to the swelling periosteum a proper *point d'appui*.

"The teeth caused no more inconvenience to the patients than the inserted dead teeth. But when the gutta-percha plates were removed, which were also worn in these cases four to five weeks, the teeth almost immediately fell out.[1] The alveolus was piled with granulations, and healed in a short time. Naturally, there was no absorption of the roots of the porcelain teeth, and the periosteum of the alveolus could penetrate only into the small artificial grooved depressions, and in the most favorable case form there into bone. This would hardly be sufficient itself to retain the tooth. In the observed case there occurred no bone-formation. The perfectly heterogeneous stone mass acted as a foreign body, producing granulation and ulceration, and thus prevented the healing in. This ulceration had been overlooked whilst the tooth was still in the alveolus, as the secretion was washed away instantly with the fluids of the mouth."

Dr. Cutler, an American observer, also claims to have found an osseous deposit upon a replanted tooth,[2] a right lower second bicuspid, which was extracted, replanted, and at the end of four weeks, in consequence of inflammation, again extracted, "some force being necessary." Dr. Cutler states that "on one side there was a small patch of bone firmly adherent, and also some soft tissue. The bone under the microscope showed true bone-structure in lacunæ. The canaliculi were not quite perfected, owing to want of proper time for their formation."

That in either of these cases there was a true osseous formation is hardly probable, the deposit being, doubtless, more in the nature of calculus.

The third view, that the retention of either a replanted or transplanted tooth is simply mechanical, and due to a contraction of the alveolar walls upon the root (a view which, according to Mitscherlich, was defended by Von der Hamel, Pauli, Jourdan, Pfaff, Richerand, Lisfranc, and many others), appears to be, in the light of modern pathology, hardly satisfactory or sufficient to account even for the temporary strength of the attachment. A much more reasonable explanation is embodied in the following views, which have been kindly contributed to this paper by Dr. Sudduth. Substantially the same views are held by Dr. Black:[3]

"First, in order that we may have an understanding of the subject in hand, it is pertinent to inquire into the nature of the attachment of teeth under normal conditions.

[1] "With much trouble Dr. Suerson has remodelled for me a number of porcelain teeth in such a manner that they correspond in their form to the incisor teeth of man."

[2] See "The Transplantation and Replantation of Teeth," by S. P. Cutler, M. D., D. D. S., *Dental Cosmos*, May, 1877.

[3] See Vol. I. p. 986, 987.

"Teeth are held in position in the alveoli by the peridental membrane, which unites with the alveolar wall on the one side and with the root of the tooth on the other. Bone and cementum are analogous structures. They are not solid bodies, but are permeated by numerous canals, which here and there widen into larger cavities known as lacunæ; these canals are called *canaliculi.* The contents of the lacunæ are termed *bone-cells,* and the canaliculi locate the processes of the bone-cells. The same is true of the cementum, which covers the dentine of the root. The fine processes of the bone-cells anastomose with the processes of other bone-cells. Union is also formed in a similar manner with the peridental membrane and the cementum on one side, and the alveolar wall on the other; thus the tooth is held in place. Some teeth are held more firmly in position by reason of the curvature of their roots; these we are not considering, as by reason of such curvature they do not form good examples for transplantation. So much for the normal attachment of teeth. In teeth which have lost their pulps while yet *in situ* there is no change in the character of the attachments of the tooth. The dentine of the root, although its living tissue be dead, is still covered by the living cementum, and consequently does not alter the normal condition of union between tooth-root and alveolar wall. If the contents of the pulp-canal are not removed and a suitable filling inserted, a condition of inflammation may be set up which will in time result in the death of the soft parts of the cementum also. If the inflammation is controlled and a healthy condition is established, then the relation of that tooth is analogous to that of a replanted or transplanted tooth which had remained out of the mouth for a sufficient length of time for the pericementum and the soft tissues of the cementum to die. The canals in which were situated the processes of the cells of the cementum are now empty, and into these the fine processes of connective-tissue cells which fill the alveolus force their way, and thus the attachment is made. Of necessity, such an attachment is not as firm as the union of cementum and pericementum under normal conditions. In the case of a transplantation of a tooth more or less inflammation is set up and granulation-tissue fills in the interspace between the sides of the tooth and the alveolar wall, and retention results the same as in replanted teeth. If the tooth transplanted is an artificial one, having a polished root with a rounded knob upon its end, the same inflammatory action spoken of will encapsule the artificial root, which by reason of its shape and the fact of its having been polished will be held *in situ,* but not so firmly as the natural tooth.

"If the root of the artificial tooth be left unpolished or notches cut into its sides, as has been often done with the idea of better retaining it, then by reason of these rough places and surfaces the root becomes a source of constant irritation and is thrown off. It is a well-known fact that polished non-irritating bodies do become encapsuled and retained in the body for years. An artificial tooth-root may be rightly prepared and encapsuled, yet when the root is put to use it soon becomes a source of irritation and the attachment is of short duration. If teeth are replanted immediately after extraction or removal by accident, before the death of the pulp or pericementum, I see no reason why a union may not be established between the root and alveolar wall not only, but also between the nerves and vessels of the pulp and the main trunks of each.

"Nevertheless, I should always consider it better practice to remove the pulp through the apical foramen, and then fill the pulp-chamber with oxyphosphate. If precautions are taken to keep the root moist and warm by wrapping it in bibulous paper which has been dampened in a slightly saline

solution, and the work is expeditiously done, the pericementum can be kept alive and a firm attachment secured."

My own experimentations have been chiefly confined to the human subject. While I have made several attempts to replant teeth in the jaws of dogs with a view to subsequent dissections, the mechanical obstacles interfering with retention have always prevented success. Indeed, Mitscherlich himself, out of many attempts, succeeded in only one instance; in all others the continual movements of the tongue and the force exercised in mastication speedily displaced the replanted tooth. With the human subject the conditions are much more favorable for at least the temporary retention of a replaced tooth; but I have found that however firmly a replanted or transplanted tooth becomes attached to the socket, that attachment, as a rule, is of comparatively short duration. In the mouths of adults they are specially liable to drop out, either without any apparent cause or as the result of a sudden, unlooked-for, and violent inflammation. A tooth replanted in a socket having a very thin labial or buccal wall requires, as a rule, more time to become firmly held in position, and, according to my experience, such cases, more frequently than others, result in total failure, the tooth finally dropping out without even the semblance of temporary union.

I have replanted between seventy and eighty teeth, of which only two failed of retention in the alveolus. These extractions and replantations were performed chiefly for the purpose of, as I then believed, more successfully engrafting porcelain crowns upon the natural roots.[1] The brilliant demonstrations by Bödecker of the existence of living matter in the human dentine and cement, and the fact that there is no essential difference between the lacunæ and canaliculi of ordinary bone and those of cementum,[2] led me to place implicit confidence in the re-establishment of a full vital relation between the root-investments and the alveolar walls. I also thought to derive still further advantages from the greater facility the extraction of the root afforded for the more thorough and efficient removal of putrescent matter from the pulp-chamber and canal, and, in pulpless teeth, of the excision of the zone of dead dentine continuous with living protoplasmic bodies in the cementum, and so diminishing very much the chances of pericemental irritation, because I believe that the pericementum surrounding pulpless teeth is susceptible to irritation and inflammation just in proportion to the amount of dead tissue left in the root; and it still remains true that its thorough removal can be more rapidly and safely accomplished out of the mouth than in it; the same remark holding good as to the mechanical details of engrafting the porcelain crown. But in the final test, permanency of result, replanting teeth has in my hands proved a signal failure. The details of the process as practised by me may be here briefly stated:

The root of a tooth, with or without a partial crown, was first extracted; the decayed portion cut squarely off with a corundum wheel or saw just at the lingual and labial points of enamel that extend toward

[1] See "Replanting and a New Process of Engrafting Porcelain Crowns on the Natural Roots," *Dental Cosmos*, June, 1879.

[2] See *Dental Cosmos*, December, 1878.

the apex of the root, and in all cases where no absorption of the alveolus had taken place directly under the margin of the gum. A porcelain crown, with a tapering screw made of platinum and iridium, which had been securely baked in the centre perfectly parallel with its length (see Fig. 239), was then firmly screwed into the pulp-canal of the root, the pulp having first been removed and the canal enlarged by reaming out with an engine reamer. To facilitate the introduction of the screw, a preparatory thread was cut in the root with a tap. This process established a very strong attachment between the natural root and porcelain crown, and with the additional aid of cement in the canal it was made perfect. When this operation was completed (which required from fifteen to twenty minutes) the socket was syringed out with tepid water, and the root with the new crown attached was gently but firmly pressed into its original position; one of the principal objects for extraction was to secure by mechanical means a perfect and less expensive attachment than obtained while the root remained in the mouth.

Fig. 239.

After this manner was treated the tooth A, B, figured in Fig. 240, which may be taken as a typical case so far as treatment and results are concerned. The operation was performed for a young man æt. twenty-eight in October, 1878, the tooth (a natural root with porcelain crown attached) doing good service for over a year, and during that time remaining so firmly attached to the alveolus as to make it a question in my mind whether it was not firmer than any one of the other front teeth. In a little over a year's time, however, the tooth began to loosen in the socket, and in about five months thereafter the patient removed it with his fingers.

It will be observed that the cementum on both sides of the roots presents bay-like excavations, more decided upon one side than upon the other. These evidences of absorption are generally found upon replanted or transplanted teeth which have been worn for any considerable length of time; indeed, they generally make their appearance after the expiration of a few months.

The following interesting series of figures is illustrative of the same process. They are taken from a paper by Dr. William Herbert Rollins of Boston.[1] The tooth figured in 241, 242, 243, and 250 was presented to the Harvard Dental School Museum by Dr. Cogswell, and its history, as given by Dr. Rollins, is as follows:

"Its owner was a male of middle age. The tooth was extracted for pulpitis, the decay being so extensive as to render filling out of the question. Finding a union of the roots, Dr. Cogswell decided to try replacing, as the tooth was of great importance, there being no other molars on that side of the inferior maxilla. To see if the tooth would return into the socket easily, it was pressed into place, after which it was removed from the mouth, the pulp extracted, the root and crown filled with gold, the ends of the united roots polished slightly, and then again placed in the socket, after having been out for three hours. The next day the tooth was employed in masticating beefsteak, while from the time of its replacement, for five years and eleven days, there was no sign of inflammation of the root-

[1] See *Dental and Oral Science Magazine*, August, 1878.

FIG. 240.

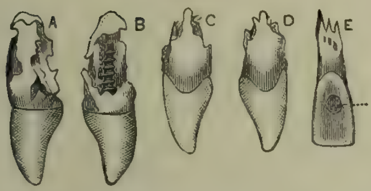


FIG. 241.

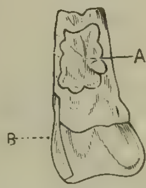


FIG. 242.

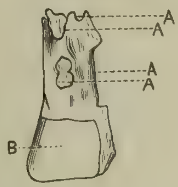


Fig. 240. C, D, E, show the manner of absorption of a root of a *transplanted* tooth after eight months.
FIG. 241. Inferior Right Third Molar, extracted and replaced, after which it was worn five years and two weeks without being lame, until three days before last extraction: A is a large cavity formed by the absorption after the tooth was replaced; B, gold filling.
FIG. 242. Another View of the Same Tooth: letters as before.

FIG. 243.

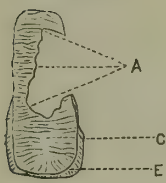


FIG. 244.

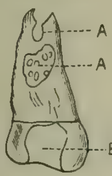


FIG. 245.

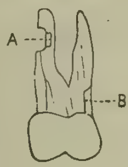


FIG. 246.

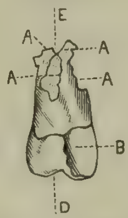


FIG. 247.

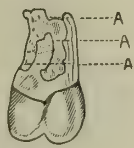


FIG. 243. Section of the Same Tooth, to show the extent of cavity A in Fig. 241; C, dentine; E, enamel.
FIGS. 244, 245. Two Views of a Tooth which was extracted and replaced, but after being used two years was again removed; letters as in former figures.
FIGS. 246, 247. Two Views of a Tooth which was extracted and replaced; letters as before.

FIG. 248.

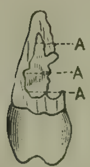


FIG. 249.

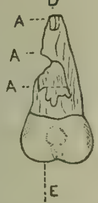
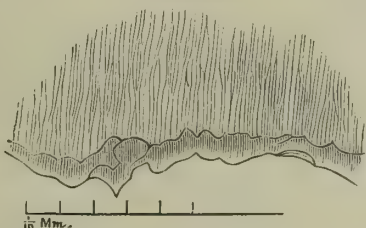


FIG. 250.



FIGS. 248, 249. A Reinstated Molar; letters as before.
FIG. 250. Section from Tooth shown in Figs. 241, 242, 243; shows marks of absorption. Section corresponds to the deep surface of the cavity A in Figs. 241 and 243.

FIG. 251.

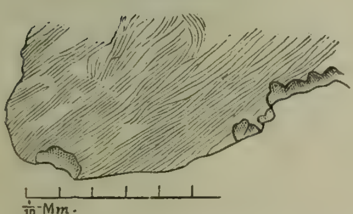


FIG. 252.

FIG. 251. A Section from Tooth shown in Figs. 244, 245: plainly to be seen are the marks of absorption.
FIG. 252. Section through the line D E, Figs. 246 and 247, perpendicular to surface shown in Fig. 246. The lunated edge corresponds to the deep surface of the cavity A in Fig. 246.

FIG. 253.

FIG. 253. Section through line D E, Fig. 249, perpendicular to the surface of Fig. 249. The new formation of cement-like tissue, A B, corresponds to the deep surface of the cavity A in Fig. 248. F L, excavationes lunares filled with cementum-like tissue.

membrane; but three days before its final removal, when it came away with the exercise of only slight force, it suddenly became very painful, preventing closure of the jaws; nor would the inflammation yield to any of the therapeutical agencies employed."

In commenting upon this case Dr. Rollins says:

"This suddenly-appearing pain and lameness occur in a great majority of those teeth which, after being replaced, become firmly reunited with the body; in fact, Dr. Waters, who has had quite a number of these cases, has found this symptom in every one."

The process by which the erosions upon replanted teeth are formed is not fully determined. Dr. Rollins states that "the microscopical changes wrought by it cannot be distinguished from that absorption seen in deciduous teeth with living pulps," and claims that "these lunar excavations seen in teeth with dead pulps are produced, as they are admitted to be in teeth with living pulps, by the agency of living cells."

This is the teaching of modern pathology, the probability being that these cells, "giant-cells" or "osteoclasts," secrete erosive fluids, which, acting upon the organic as well as inorganic constituents of the devitalized tooth-substance, produce their gradual decomposition, solution, and absorption. The process has its parallel in the erosions found upon osseous sequestra which have been imbedded in living tissue.

The conclusions which I have arrived at with regard to the practice and phenomena of replantation may be thus summed up:

1st. That replanted teeth will, as a rule, speedily reattach themselves and become firm in the alveolar sockets from which they were taken; but the length of time they remain in a useful condition varies in each individual case, and is dependent on the constitution and age of the patient and local and systemic conditions.

2d. That a full vital relation may sometimes, though rarely, be re-established, but that usually it exists only during that period of time after extraction when the root approximates a natural and normal condition, and terminates with the death of the peridental membrane

and the protoplasmic constituents of the cementum and dentine; the tooth then becoming a foreign body, and gradually undergoing disintegration through the action of giant-cells or osteoclasts.

3d. That devitalization of the peridental membrane, cementum, and dentine usually speedily follows replantation, the tooth being then retained in position by granulations from the soft tissues penetrating the lacunæ and canaliculi of the cementum.

4th. That the severance of this connection and the failure of the operation may be due either to the gradual loosening, resulting from continued oscillation, or to the supervention of acute inflammatory processes to be arrested only by the removal of the foreign body.

5th. That in view of the possibility of danger and the certainty of ultimate failure attending this class of operations, the practice of replantation, either for the purpose of filling sensitive carious cavities, the treatment of neuralgic affections, or of alveolar abscess, or for the purpose of engrafting porcelain or other crowns, is unjustifiable.[1]

[1] *Implantation of Teeth.*—Since this paper was written the operation of implantation has been brought prominently before the profession by Dr. W. J. Younger of San Francisco, who has given this name to the process devised by him of drilling artificial sockets in the maxillary bones and placing therein natural teeth of suitable size, shape, and shade. Dr. Younger first performed this operation in 1881, and the tooth still remains firmly attached. Since then he has successfully implanted a large number of teeth, and has had but few failures. His method is to carefully dissect from the bone all the overlying soft tissues, they being left attached in the form of a continuous flap, which when the tooth is in position grasps its neck and assists in its protection and support. The socket is drilled by graded trephines and burrs adapted to the size and shape of the root to be implanted. The pulp of the tooth is removed and the canal filled with gutta-percha, the apex of the root being finished with gold. The tooth is placed for about fifteen minutes in a bath of bichloride of mercury, 2 parts to 1000 parts of water, at the temperature of 110° F. All instruments are bathed in the same fluid, and the socket is washed with it, first carefully rinsing out all fragments of bone with warm water, and then using cold water to check the bleeding. The tooth is then placed in position, and if necessary is attached with ligatures.

Dr. Younger's theory regarding the nature of the attachment formed is, that the natural alveolar socket has no periosteum, and that the filling out of sockets comes from the "endosteum, the delicate membrane lining the cells and interstices of the bony structure." The peridental membrane he regards as having no "callus generative energy except upon its dental aspect;" the other side, he claims, has simply the power of forming attachment. The vitality of this membrane he regards as being maintained for many months after extraction, he having successfully implanted teeth which had been out of the mouth and thoroughly dried for over a year.

Dr. Younger recognizes the uniform failures which heretofore have attended the replantation and transplantation of teeth, but claims that these failures are fairly attributable to the fact that usually in such cases the socket or the tooth, or both, have been badly diseased at the time the operation was performed, whereas in implantation a healthy root is put in a healthy socket. This argument, however, hardly holds good as to those replantations after the attachment of artificial crowns cited in this paper, in nearly all of which cases both roots and sockets were healthy, while ultimate failure was the fate of all.

EXTRACTION OF TEETH.

By THOMAS C. STELLWAGEN, M. A., M. D., D. D. S.

THE indiscriminate extraction of teeth at the hands of charlatans has been a sacrifice of such untold wealth of life that the gigantic system of malpractice has made the whole operation shunned and abhorred by many conscientious men in the profession. Still, as "all men are mortal" and growth and death act both in detail as well as in gross, the position of those who assume that all teeth can be saved, and therefore that none should be extracted, is devoid of the slightest foundation in reason or in fact. It is unquestionable that all incurably painful and dangerously objectionable teeth should be extracted, as this is the only safeguard for the patient.

That pain is inflicted is generally sufficiently well understood, and quite sincerely enough expressed by the sufferers, to warrant our passing it here without further notice than to call attention to the fact that the most expressive or pathetic or loud lamentation does not invariably indicate the most acute suffering. Often the heroism that nerves a delicate little patient to the endurance of the operation is exercised at an expense of vital energy quite enormous compared with the exhibition of the outward and visible signs of the effort being made. Practitioners must ever be upon their guard with such patients, lest they overtask the willing and apparently indifferent sufferers. Neglect of this precaution may be followed by a realization of the fact that in relieving one malady or deformity another much more serious and aggravated may be inflicted, such as chorea or hysteria, which is certainly a greater affliction than simple uncomplicated toothache or irregularity of the dental organs. To this general rule as to systemic danger may be added a very important one—to avoid as far as possible all operations for women who are performing the peculiar functions either of menstruation, gestation, or lactation. Many cases are on record where tooth-extraction is supposed to have interfered with these offices: in one case vicarious menstruation from the alveolus of the extracted tooth has been reported. Premature labors, congenital deformities, and monstrosities have been charged to the same cause. Mental agitation in the case of a nursing mother has been followed by the immediate death of her child after suckling,[1] supposed to have been due to her mammary glands having their secretions so altered by some occult reflex nervous action as to become actually poisonous.[2] The case referred to was one

[1] See Carpenter's *Physiology*, 1862, p. 742.

[2] Recently Victor C. Vaughan, M. D., Ph. D., has made known his discovery of a poi-

where the infant is distinctly stated to have been in good health prior to the motherly attention, which, designed for its nourishment, apparently proved the cause of its sudden death. From this it may be inferred that under all circumstances the husband, mother, or friend of the pregnant or nursing woman should be cautioned against permitting any but the most urgent surgical operations, or indeed anything even remotely calculated to work mischief by agitating the mother or disturbing the nerve-force or blood-flow. Finally, should such a misfortune have happened, the mammary glands should be artificially emptied once or twice by the mouth of an attendant, or, if that is not possible, then some other means, as a breast-pump, should be employed. Neglect of this simple precaution has doubtless often been followed in the nursling by malaise, sickness, or even serious illness, the cause of which may not have been carefully or correctly diagnosed. In such momentous affairs caution and care cannot be too thoroughly enjoined as a matter both of principle and policy. By ignoring any or all of these guards for the health of the person under charge, conditions may be induced which may cause those most interested to suspect the operator of being neglectful or inattentive to the very momentous duty of shielding his patients from injury, direct or indirect, and, in those most favorably disposed at least, would be a not unjust cause of unpleasant feeling or even of pronounced condemnation. On the other hand, such thoughtful heed on the part of the dentist will by its own merit entitle him to the confidence of his more intelligent patients, and effectually secure for him their affectionate regard.

It may be mentioned that many grave complications have occurred after operations that are far more simple. Sir James Paget recounts an instance where such a trifling procedure as the removal of a small cyst was followed by erysipelatous inflammation and death.[1] The slightest wound, yea, the prick of a pin, has been followed by most disastrous consequences.[2] How much greater must be the dangers that surround the extraction of even a single tooth can be inferred from a glance at the parts and a knowledge of their intimate relations with the nervous and circulatory systems. The existence of such multiform connections makes it a very grave question as to the propriety of performing the operation in cases where these related tissues are already threatened or subject to some abnormal condition, as particularly may be instanced hysteria or the hemorrhagic diathesis. This is so much the fact that most of those who are conscientious and understand the gravity of the expressions divide the responsibility by consultation with a fellow-practitioner before operating.

Certain General Conditions Unfavorable to or Forbidding Extraction.—These may be summed up as those resulting from—

I. Debility;

II. Irritability;

sonous ptomaïne, named tyrotoxicon, in cheese and milk. See Report of the Proceedings of the Michigan State Board of Health, July 13, 1886.

[1] Paget's *Clinical Lectures and Essays*, p. 65.

[2] Holmes's *System of Surgery;* Eves' *Collection of Remarkable Cases in Surgery.*

III. Hemorrhagic Diathesis;

IV. Epilepsy.

I. *Debility.*—The symptoms peculiar to this condition may show themselves in many of the organs. In our busy population the heart is frequently the seat of the manifestation, and under many circumstances we find that it is associated with some form of nervous depression. The appropriate tonic treatment preparatory to operations should be prescribed: this generally consists in the use of iron, quinine, and strychnia. Often a mercurial, such as a blue pill, before using the tonic is a most valuable preliminary. Whenever a week or more can be devoted to the use of these remedies, combined with out-of-door exercise in the sunlight and fresh air, we find an almost invariable improvement in the general health.

II. *Irritability.*—This may be local or general. It comprises the condition commonly understood and spoken of as nervousness, and not infrequently is combined with debility, or is even the outcome of that state. If strictly a local manifestation, the treatment may be confined to the application of astringents, as tincture of myrrh or galls, which, for the sake of making them agreeable, may be combined with eau de cologne or some other flavor, as oil of orris, mint, wintergreen, etc. If more decided medication seems to be demanded, the parts may be painted with diluted tincture of iodine of strength sufficient to make the impression needed, or a solution of chloride of zinc, thirty grains to the ounce of water, may be used. Touching the parts with a crystal of alum, or even the nitrate of silver, may be useful. The last-named substance has the objectionable feature that it causes discoloration, which if it touches the teeth stains indelibly, and it therefore cannot be used in the mouth without this great danger, which practically amounts to interdiction of its use unless the most troublesome precautions are taken to keep it from the teeth and to wash it off the part after the desired impression is made.

General and nervous irritability are by no means uncommonly met with, and require general treatment, which should be adopted before operating, and the patient thus be prepared for the shock. In such cases the tonic treatment may be combined with the use of the bromides in some form, a favorite prescription being the bromide of sodium or of potassium, either of which is sometimes used with marked success before the ordinary dental operation.

The operator would do well to keep constantly on hand in his office some form of valerian for the relief of the various hysterical symptoms which—more frequently in women or children, but occasionally in men—follow the extraction of a tooth. The valerianate of ammonia is very efficient.

III. *Hemorrhagic Diathesis.*—The hemorrhagic diathesis by its effect has often caused great alarm and anxiety to operators, patients, and their friends. This condition is one in which more benefit will follow from preventive than from curative treatment: the old adage most justly rates it as of the relative value of a pound to the ounce.

The generally anæmic appearance of the patient and the history of the case, which should always be inquired into with especial regard to

this particular, will forewarn the dentist and enable him to anticipate, and by appropriate medication provide against, this difficulty. This consists, in the main, in controlling the heart's action and increasing the coagulability of the blood. For this a pill of opium and gallic acid, given three times per day and for three days in succession, will generally suffice. In all cases where the diathesis is marked it should be considered serious, and microscopic examinations of the blood made to assure the operator that the normal coagulation of this fluid will follow the operation.

IV. *Epilepsy.*—In this condition it is advisable to have the presence of the attending medical practitioner or some one well qualified by knowledge and experience to take charge of the unfortunate: little else remains to be done. The precaution should be taken, if an attack comes on, to prevent the teeth being closed upon the sensitive tissue of the mouth by inserting between them some soft material, as a piece of erasing rubber, that is sufficiently resisting to prevent occlusion without danger of fracture of the teeth with which it is brought into contact.

Impairment of Function resulting from Extraction.—In considering the propriety of extraction it must be remembered that the removal of one tooth from a perfect denture results in the reduction of the value of the whole at least one sixteenth instead of one thirty-second. This proportion may be greatly increased in a mouth where there are but few teeth. The wounding of the unprotected part of the gum by hard substances in the food, as crusts of bread, crackers, etc., not alone subjects the sufferer to pain when chewing, but generally such conditions result subsequently in absorption of the gums and even the bony processes from around the adjacent teeth, with the consequent loosening of the latter. Articulate speech is interfered with most noticeably by loss of the front teeth, but it is an important factor for consideration even as far back as the premolars or bicuspidati.

The absorption of the alveolar process is likewise a very urgent and important objection to the early extraction of the permanent teeth, since this, by the subsequent flattening of the mouth, may be followed by the complication of the difficulties that accompany the adjustment and wearing of artificial dentures.

In the light of this consideration, aside from the many other advantages gained from the operation of crowning, it would seem that no one can be considered excusable for removing a moderately healthy tooth-root unless a more serious lesion than merely a broken-down natural crown impair its utility or a dead pulp threatens to bring about an abscess. Indeed, as a return to the normal condition can best be looked for after the reinstatement of the organ as a fellow-laborer with the rest of the teeth, it almost invariably follows that the properly-adjusted artificial crown proves one of the most perfect as well as natural cures for persistent tenderness, subacute inflammatory action, and, in a word, for most troubles about a tooth-root from malaise to alveolar abscess. The reasons for this may readily be understood, as the operation reinstates the tooth as a useful organ, and the natural stimulation of the pericementum and surrounding tissues which follows use is ordi-

narily the best means for bringing about a recovery of health. When deciding upon the advisability of extraction, therefore, the question of the value of the tooth as a means of mastication, of expression, or of articulate speech, also as it effects the contour of the face and general utility, should be most thoroughly and carefully considered. The absence of an antagonist and the possibility of successfully substituting something against which the tooth may be made to bite are very important considerations in deciding as to the preservation or sacrifice of the organ. The dangers from shock, hemorrhage, and injury or impairment of the general system should also be taken into consideration.

The premature and injudicious extraction of the deciduous teeth has in the past been a fruitful cause of irregularity of the permanent ones that succeed them. The removal or non-removal of the teeth should be governed by a general summing up of the reasons for retention and extraction in each particular case, these being grouped under their respective heads, and a balance struck.

Probably no operation in dentistry requires more latitude and breadth of knowledge for formulating a correct judgment than extraction. The decision as to the irreparability of a tooth never should be made without giving the implicated organ the benefit of any doubts that may arise. If an error be made, it is generally irrevocable, as the execution frequently follows so soon upon the verdict that it cannot often be reversed or revised. So many teeth, that have been condemned, have afterward proven to be partially or completely useful for years after they have been pronounced valueless and even injurious, that the evidence is overwhelming in favor of the greatest conservatism of practice. There are legions of teeth showing how under proper treatment they almost universally recover, although before that time they had been surrounded by malignant-looking gums emitting putrid discharges of decomposing pus, which flowed night and day from fistulæ leading through the bone to the roots, apparently threatening immediate danger of caries or of some form of malignant disease. Sometimes, though very rarely, this condition is the best reason for extraction and replantation after the removal of the roughened or diseased portion of the end of the root, which by its harshness serves to increase the irritation and prevent repair. A tooth so treated, for weeks may be held in position by ligatures or a piece of rubber dam with holes so cut as to allow it to be passed over and tied to the adjoining teeth, the centre being stretched like a hammock over the cutting edge of the replanted tooth, so as to hold it up into the alveolus. One instance of the firm reattachment of such a tooth to its alveolar walls and its retention for more than four years has recently been examined in the writer's practice, and as it had again loosened it was a second time successfully held in position until it had grown moderately firm. Hence this may be given as one of the reasons for extracting teeth, which may all be summed up in a few

Rules for Extraction.

I. When a tooth becomes so much loosened in its socket as to be very painful when bitten upon, and when it persistently grows worse

in spite of all treatment, it may be extracted. If the tooth be a permanent one, all abnormal deposits should be removed, the apex of the root shortened, smoothed, and then replanted.

II. Teeth may be extracted to prevent or correct irregularity. This is particularly desirable when the dentine is soft, as we may hope for improvement in the texture of the remaining denture.

III. Teeth whose pulps cannot be removed, and which are the subjects of incurable disease, either unbearably painful or dangerous in character, may be extracted, filled, and replanted.

IV. Teeth should be extracted that cause or are about to cause irremediable, painful, or dangerous disease of the hard or soft parts with which they are related.

Rule I. *When a tooth becomes so much loosened in its socket as to be very painful when bitten upon, and persistently grows worse in spite of all treatment, it may be extracted. If the tooth be a permanent one, all abnormal deposits should be removed, the apex of the root shortened, smoothed, and then replanted.* The capability of the alveolar walls for repair is most remarkable, particularly around children's teeth. In the case of one of the writer's children the same deciduous incisor was twice violently driven up into the bone, the result of falls, and each time upon being drawn down by forceps grew firm, and was retained for several years until the permanent substitute was nearly ready to erupt; after eruption it was found not to have been injured by the violence to which its predecessor had been subjected.

The deciduous tooth rarely needs to be removed until the permanent successor comes so near the surface as to be readily felt upon piercing the gum with a sharp needle. Teeth of the first dentition, even after severe injuries, will generally recover and serve their purpose until near the time of the appearance of their successors. Portions of the roots of the deciduous teeth denuded, as the result of wasting by absorption or by ulceration and sloughing of the overlying tissues, have frequently been cut off and their remaining ends polished to prevent their causing diseases of the tongue or of the soft tissues of the cheeks in contact with them. The same procedure has been successfully practised with the permanent teeth, and in some cases where there was more than one root, a denuded, loose, and very defective root has been cut off from its attachment to the crown, and then extracted, leaving the balance of the tooth in position, where, for years, supported by the remaining root or roots, such teeth may do good service. Sometimes the operation of extraction may be avoided by connecting the crown of the affected tooth with its neighbor or neighbors on one or both sides by means of ligatures of silk or by wires, by rivets or bridges of gold amalgam, or gutta-percha, or by combinations of these.

Extraction or removal of the whole of a tooth is no more justifiable on principle for the disease of a portion than the amputation of a hand is to be resorted to for the cure of a diseased finger. Indeed, now that the burring engine has been so perfected it may become the duty of the operator to cut off the diseased end of a root, allowing the balance to remain in situ, an operation ingeniously described by Dr. W. H. Howard.[1]

[1] *Dental Cosmos*, vol. xi. p. 134.

The operator should ever bear in mind the fact in these cases, that so long ago as the epochs during which the temple of Delphos flourished the importance of allowing moderately loosened teeth to remain in the mouth was impressed upon the student and practitioner by the exhibition of a pair of leaden forceps.[1] The numerous and important improvements in crowning and bridging by which roots are now made serviceable, and loose teeth retained in position until they may again form firm attachments to the jaw, all combine to make it imperative that the operation of extraction of loosened teeth shall grow less and less frequent. Indeed, it rarely happens that the ingenuity of the dentist is compelled to acknowledge itself as baffled in these cases.

The operation, when carried out for treatment of root and replantation, should be so carefully and gently performed as to injure the surrounding parts as little as possible, and, furthermore, is generally so simple as scarcely to require any further directions for its accomplishment than the making of efforts in different directions, gradually increasing in force, until the line of slightest resistance is discovered and the tooth-root is slowly and deliberately drawn out from the alveolus. This rule may occasionally be impossible to fulfil, so far as the latter part or the replantation of the tooth may be concerned; and while it is very rare indeed that such proves to be the case, it is advisable that the operator should take the precaution to protect himself from the possibility of a reflection upon his skill by the patient. There must always be the greatest care not to hold out too positive inducements or any assurances of success.

Cases are by no means infrequent in which the absence of antagonizing teeth is the cause of what is improperly called elongation. This is simply the rising up from its socket and the gradual obliteration of the alveolus by growth of bone in the part from which the tooth-root has been extruded, and is generally followed by extreme loosening and eventual loss of the organ. Sometimes, however, before this process is completed the crown of the tooth may impinge painfully upon the gum or soft tissues of the mouth. Instances of this character may justify the extraction of the offender, but if the patient applies in time it is wiser to arrange a denture or plate to protect the opposing gum or tissue, and thus partially restore the usefulness of the tooth. Where the latter cannot be done it is a comparatively simple operation to cut off the offending portion of the crown and prolong any remaining utility of the tooth.

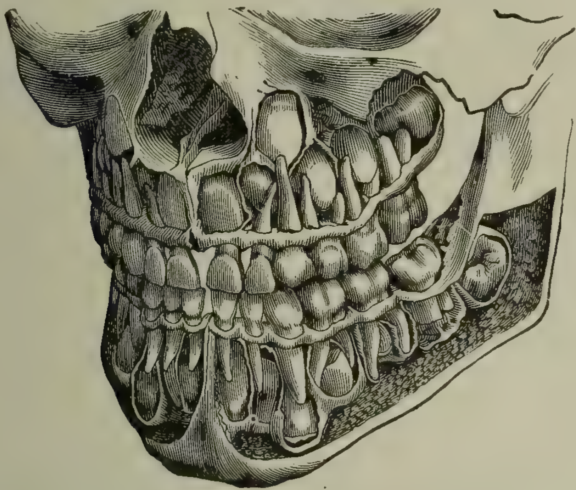
Rule II. *Teeth may be extracted to prevent or correct irregularity.*—Here is not infrequently found a paradox in the fact that it is not always wisest to remove the tooth that is irregularly placed, particularly if it is the cuspid, for its great value for use in mastication, for contour, and for expression of the face, and its long life, it being generally the last tooth to succumb to disease, combine to give it a physiological value far above either of the adjacent teeth, the lateral incisor or the first bicuspidatus. It would seem that one of these, when the arch is crowded, should surrender its position to this more valuable brother, as the place of either one is quickly filled by him, and their absence is scarcely appreciable

[1] *A Practical Guide to Operations on the Teeth,* by James Snell, p. 4, Philadelphia, Carey & Lea, 1832.

to any but an expert, so perfectly does the space become filled. The importance of estimating the probable or prospective value of the different teeth in connection with an operation has caused many writers to arrange tables as to the relative longevity of the individual teeth, and while every mouth, and each tooth in it, is a separate study, these tables are useful on general principles, like those from which life insurance is computed.

The study of the development of the teeth and their eruption (Fig. 254) is here of practical importance, since the crowded condition may

Fig. 254.



View of the Upper and Lower Jaws of a Child aged about six and a half years. The external portions of the bones have been removed to show the positions of the developing permanent teeth and the fangs of the temporary teeth. The bifurcation in the fangs of the upper cuspidati is abnormal. (From *The Mouth and the Teeth*, by J. W. White, M. D., D. D.S.)

be such as to cause us to hesitate between choosing one of two teeth seemingly about equally irregular in position. Remembering the order of the formation and appearance of the teeth through the gum, we may upon this almost invariably predicate that the advance of the second molar to the position of the first, or the third to that of the second, would more readily take place than would a reverse movement. This consideration is of self-evident importance before extracting, and neglect of it is liable to be followed by the gravest difficulties.

As a further precaution, the interlocking of the cusps of the teeth must be considered, for they act as would inclined planes or wedges, and therefore not unfrequently tend to prolong, or even exaggerate, the malocclusion and make the condition permanent.

It is true that by means of mechanical contrivances, aided by persevering endurance on the part of the patient, the cusps may be brought into occlusion in the manner that may be desired. As an offset to this it should be avoided as a task expensive alike both to the patient and operator—painful, perplexing, and vexatious—the termination of which generally may be summed up as resulting in so much inflammation or alteration of the conditions of the apices of the teeth-roots and their

surrounding tissues as to permanently cripple them, leaving them, even if ornamental, yet too tender upon pressure to be more than ever-present reminders of the uselessness and the folly of the suffering which the unhappy possessor was urged, and indeed often compelled, to undergo by the misjudgment of the dentist. Frequently, too, by early attention the whole trouble may be prevented. We look with aversion upon the deliberate deforming of the Chinese women's feet, and brand it as a barbarous custom, but this false valuation of the regularity of appearance of the teeth often has even less to recommend it.

The expansion of the upper jaw, if it can be effected without disturbing the harmony and balance of the face, seems to be the most proper solution of the problem; but it must be practised in a rational manner, and not merely consist in the separation of the apices of the teeth-crowns like the opening of an umbrella frame, leaving the ends of the roots in their original positions, and frequently in a condition of chronic tenderness as irritable under pressure as a clavis or corn.

The opposite condition to that just considered, or the retraction of the lower jaw, is a state often regarded as the result of reckless extraction of the teeth; and this idea is seemingly sustained by the well-known and established law that arrest of development follows in proportion as a growing organ or group of organs may have been deprived of natural use or exercise. The action of the tongue, however, generally is sufficient to expand the lower maxilla.

The treatment of malocclusion, as exhibited in the protruding lower jaw, may be much facilitated by judicious removal of teeth; and, conversely, the deformity can be brought about by, and often is the result of, injudicious extraction. Sometimes, too, it may be the outcome of the protrusion of the lower jaw by the undue cultivation of those muscles which draw it forward for masticatory purposes, and cause the front teeth to perform unnatural labor, the lower ones having eventually fallen into such relations with the upper, as regards the inclined planes of their cusps, as to prevent their natural occlusion.

This unsightly appearance is eventually made permanent by the expansive growth of the bone in response to the spreading of the arch of the lower teeth. Generally, this arrangement, so contrary to the normal condition, crowds the upper teeth into a much contracted arch. The extraction, therefore, of some of the lower teeth (generally bicuspidati or molars), if performed at the proper time, may alone be all that is necessary for correcting this deformity. This, however, is rarely attempted until too late for natural orthodontia. The extraction is then merely a preliminary step to obtain room into which to draw back the anterior teeth—just as the removal of segments of an arch, and the subsequent coaptation of the remaining portions, reduces the size of the same.

The early period of life at which most of these operations are demanded if the finest results are to be obtained is probably the greatest drawback to the practice. Both parent and child are only too ready to delay, or even refuse to allow, any painful present infliction, as they term it. The course generally adopted is to beg the question by satisfying themselves that it will be time enough by and by, which frequently means when the trouble has become advanced sufficiently for

them to recognize it; in other words, until it is too late to obtain the best results by the least painful methods.

Closely related to the discussion of irregularity, although not definitely understood as a part of the subject, are the arguments for and against the retention of the first molar.

The Extraction of the First or Sixth-year Molar Tooth.—The discussion of this subject may be premised by reminding the student that this tooth may be looked upon as the connecting-link between the first and second dentition. Although it is classed as a permanent tooth, the early period of life at which it is erupted, it often being seen shortly after the fourth year, is at once a sufficient explanation of the softness of its texture and the defective arrangement and substance of its enamel-prisms. There are no better means of estimating the probable duration or life of a tooth than to remember the general rule, that the time required for its development and growth may be considered as usually proportioned to that of its existence. Hastily-formed teeth are subject to the same disadvantages as hastily-erected buildings.

Rule Second may be supplemented by the statement that the extraction of some of the teeth where they are formed of unusually soft dentine appears to be almost invariably followed by the very marked improvement in quality of the remaining ones. The pruning of plants, the frequent close cutting of the hair—or, in other words, the diminution of the quantity of tissue to be nourished by a certain definite supply—tend certainly to make the remaining tissue more perfect and dense. Nowhere do we see greater lavishness than in the development and growth of new tissues: everything in the pregnant woman is secondary to the welfare of the fœtus, and the very bones, teeth, and life of the mother are not excepted from the tax levied upon her frame for the building of that of the new being.

Nowhere does this law of the necessity of restraint to prevent over-development more uniformly exact obedience or become more capable of definite demonstration than in arboriculture, where the most careful and constant pruning is rewarded by healthy, vigorous, and sturdy growth. The tendency of Nature to extensive formation of shoots and branches is in the uncultivated tree subject to limitation by decay, but man by systematic and generous feeding and pruning has improved upon this wild and uncertain means. Of course, the full complement of teeth is most desirable where by the abundant supply of healthy nutriment they can all attain perfection; but where, through weakness or vice of the organs that digest, or of the circulatory system that distributes, or of the tissues that assimilate nutritive material, there may often arise a necessity for the reduction of the amount of the dentine to be nourished by the removal of some of the teeth, the selection of the crowded and the most defective teeth would be in accordance with our understanding of the law of Nature.

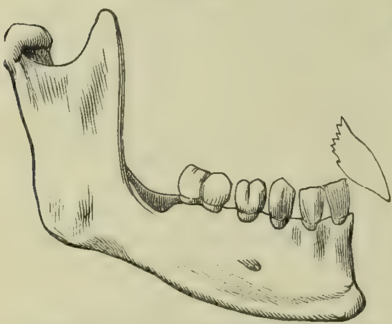
Some years since there was a series of discussions as to the propriety of the extraction of the sixth-year molar tooth, and the most able summary known to the writer will be found in a paper upon this subject by Dr. Louis Jack.[1] The whole discussion may be summed up as hang-

[1] *Dental Cosmos*, for May, 1874, pp. 252, 253.

ing upon the question of the value of this tooth in all its phases and all the different conditions of the mouth; also the change in the arrangement of the teeth that supervenes upon the extraction—the loss of it from the jaw both as it effects mastication and symmetry.

As this is the largest of all the molars, it would be by far the most valuable of all the teeth were it not so generally inferior in its texture. Its period of greatest utility is during the six years intervening between its eruption and the appearance of the twelfth-year molars, as it is the principal grinder, by reason of the shedding of the deciduous molars, but later its fellow-molars, the twelfth-year and wisdom teeth, in great measure replace its loss. The digestive apparatus may be seriously impaired if this molar be extracted during this critical period, as dyspepsia and its attendant train of ills of malnutrition are much more grave at this age, when development and growth need so much of healthy tissue-producing material. Finally, by throwing the major part of the work of mastication upon the anterior teeth, it causes an abnormal growth of the jaws, making the lower protrude and grow heavy in front, giving to the face a grim or even bull-dog or apish expression, from the preponderance of the animal rather than the intellectual in the features. The lower incisor teeth often drive the upper outward, as shown in Fig. 255.

FIG. 255.



Deformity from too Early Extraction of Sixth-year Molar. (From *Dental Cosmos.*)

FIG. 256.

Deformity from Extraction of Sixth-year Molar, after the eruption of the twelfth-year molar. (From *Dental Cosmos.*)

The growth of the body of the jaw back of the bicuspids is not as it would be when in more vigorous use in supporting these working teeth.

Upon the opposite hand, if the extraction of the tooth be delayed until the twelfth-year molar is erupted, the gap (Fig. 256) made by the tilting of that tooth forward and of the bicuspid backward leaves a triangular space (shown in Fig. 256), which is calculated to retain food, the decomposition of which causes defects of the proximate surfaces of these teeth, which from their inclined positions are among the very difficult places for the dentist to fill. The lower jaw is liable to be contracted at this point by the cicatrix; the defectiveness of the position increases; and later on the distal angle of the molar receives in mastication the pressure of the antagonizing tooth, and is unable to stand erect as Nature designed.

From the study of these conditions it is evident that when the teeth are crowded and the sixth-year molars are of a weak and soft structure, as shown by large cavities that threaten the exposure of the pulp, necessitating its devitalization before the patient's twenty-fifth year, it is well to practise extraction of these four teeth just about the time of the eruption of the second molars, which will move forward later and fill the vacancy. Should this critical period be passed and the twelfth-year molars be in position, the operation must be deferred until the eruption of the wisdom teeth, with the reasonable expectation that the second and third molars may be depended upon to move forward. Meanwhile, however, where there is a tendency to crowding much proximate surface decay of the teeth may occur, and the damage be almost irreparable. The teeth seem to harden better if the extraction is performed at the earlier period, and it is a work of supererogation to furnish arguments proving so self-evident a fact as that twenty-eight healthy, sound, strong teeth are better than thirty-two weak, defective, and faulty ones.

Of course it may happen—but experience shows it to be only in very rare instances—that the patient's general health may improve. The occurrence of this in some few isolated cases has encouraged very sanguine operators to battle along, filling and refilling the teeth that may need the attention of the dentist. Careful study of cases, however, has shown almost universally that the increased suffering borne while undergoing the dental operations, and the long continuation of the discomforts, all combine to overcome the ambition and hope that sustain the patients. Once disheartened, the sufferers abandon themselves to despair, and the ruin of most of the dental organs soon follows. In those cases where the improvement has been made, a change of habit, diet, or residence has often done more than anything else to effect the tissue-hardening.

Rule III. *Teeth whose pulps cannot be removed, and which are the subject of incurable disease, either unbearably painful or dangerous in character, may be extracted, filled, and replanted.*—Fortunately, the cases illustrating the above conditions are daily diminishing in frequency, and it now rarely happens that the alternative of extraction becomes unavoidable. It is of course not within the province of this article to describe the treatment of such cases before it is decided to sacrifice the tooth. It does, however, comparatively often happen that the safest, most expeditious, and, strange as it may seem, the surest and least painful, method of treatment is to extract the tooth, remove its pulp, fill the cavity and canals, and then replant the organ after having shortened and rounded off the apex of the root. The use of a gold screw fitted into the enlarged apical foramen, and then cut off flush with the end of the tooth-root and the whole burnished, has proven to be an expeditious and exceedingly efficacious means of preparing the root for replantation.

It is not always necessary to lift the tooth completely from its socket to sever the pulp-connection, and where the remainder of the operation can be readily accomplished without it, the work is simplified and the danger of inflammation much diminished.

Rule IV. *Teeth should be extracted that cause or are about to cause*

irremediable, painful, or dangerous disease of the hard or soft parts with which they are related.—This condition, although rare, is generally so serious that it has been thought well to enumerate it as among the causes for extraction. Oral tissues presenting ulcerated surfaces, often turgid with blood, or even hard and lobulated—in a word, threatening degeneration into some form of cancer—have been almost immediately cured by removing the irritation produced by a ragged tooth, by rounding off and smoothing the edges which impinged upon the spots and kept up the excitement. The recovery seemed almost magical, but few would have risked the attempt except the very confident and thoroughly sanguine practitioner. The risk attending a few hours' or days' delay to enable the oral surgeon to determine by experiment the effect of the treatment is not so great as to deter one from recommending the practitioner to make haste slowly in these cases, and to remember that the dyspepsia and other manifold difficulties following upon the loss of masticating organs may be much more serious than the mere irritation of a mucous membrane. In a word, the value of the teeth has come to be more and more highly appreciated as the science of dentistry is more advanced, and the connection between the state of the alimentary canal and that of the general health, as long known, is now comprehended and understood to depend very largely upon the efficiency and perfection of the teeth.

This latter proposition is daily being better understood by the masses, so that it is rather the wonder that so many of those classes (the very busy people) who formerly had their teeth removed at very slight notice and for very trifling causes now hold on to them with an almost desperate grip.

Under this rule may be classed the cases where it was the practice to extract a molar tooth for antral difficulty, and treat that cavity through the opening made in its floor through the alveolus. More recently it has been shown that the entrance to the antrum can be so readily made through the external wall just above the teeth by means of the dental or surgical engine-drill, that the excuse no longer exists that once did for the removal of a comparatively good tooth in order to reach the diseased part and enable the same to be medicated. The rule given above is designed to cover such cases as are caused by the tooth, but to exclude all excuses for the reprehensible carelessness by which an innocent and useful tooth is for mere convenience condemned to be extracted.

There are many cases reported of reflex affections of other organs which seemingly have been cured by the extraction of teeth or roots. An abundance of both rational and scientific reasons have been given in explanation of the occurrence of such complications, and it is proper that those who desire to more fully follow up the operative branch should be fully acquainted with this subject.[1] Some of the cases reported are sufficiently amusing as well as instructive. The web and woof of life are so intricate as to make the responsibility incurred by a partially or defectively educated man very grave if he dares to meddle with even

[1] See paper "On the Relations between Dental Lesions and Diseases of the Eye," by Henry Powder, M.B., Lond., etc. etc., *Transactions of the Odontological Society of Great Britain*, vol. xvi. No. 1, read before that body November 5, 1883, pp. 11–30 *et seq.*

the familiar and every-day functions of the body or its most simple organs.

Dr. Hyde Salter reported a lower molar tooth as having caused pain in the patient's arm. Dr. Benjamin Rush relates a case of rheumatism of hip-joint or neuralgia of the nates cured by extraction of a tooth. M. Petot thought a case of megrims was cured by extraction of crowded supernumerary teeth, and he likewise credits difficult and vicarious menstruation as being connected with dental trouble. I well remember an attack of apoplexy in a patient much debilitated from Neapolitan fever which supervened upon the death of capped pulps in the superior second molar and wisdom teeth, and which stubbornly refused to improve until these were extracted, after which operation the recovery was too marked to be forgotten, and too sudden to leave much doubt as to the exciting cause. Stiffness of the articulation of the jaw from trouble in a wisdom tooth is not uncommon, and trismus has followed upon treatment and filling of teeth, and also upon replantation. Tetanus and death are reported as having followed pivoting. It seems pretty generally admitted that headache, vertigo,[1] chorea, hysteria,[2] wry neck, epileptiform attacks, strabismus, amaurosis, deafness, gray hair, menstrual troubles, ulcerated mouth,[3] and insanity[4] have been developed from what was probably a natural tendency being stimulated or brought into action by tooth-trouble. Friedberg relates a cure of double neuralgia of the fifth pair of nerves after the extraction of several painful teeth,[5] and the cure of intermittent fever and counsmption may be accepted as possibly following an improvement of nutrition after the removal of a tooth that had been a hindrance to mastication.

The Extraction of the Deciduous Teeth.

The extraction of the deciduous teeth may be said to be reduced to the very simple proposition that should govern in all cases where the surgeon's art seems to be demanded. Whenever Nature plainly needs assistance, and only then, should any operation be undertaken, and it should be limited strictly to that of removing obstacles that interfere with the function of any more valuable organ or organs.

The deciduous tooth that is about to be replaced by a permanent member is the one to which the operation is generally to be limited, the operation being only permissible then when the loosening of the tooth has changed it from a useful organ to an active irritant, or where the deciduous tooth so acts as to wedge the erupting permanent one into a position that promises to constitute a lasting irregularity.

The rule has been given by some that the extraction of any tooth other than that corresponding to the one about to be erupted is never

[1] Koecker's *Prin. of Dent. Sy.*, London, 1826, p. 258.

[2] *Medical History and Treatment of Diseases of the Teeth*, Benj. Ward Richardson, M. A., M. D., p. 92, London, 1860.

[3] Drs. Blurer and Delaroche, 2d number *Bibliothèque germanique Medico-Chirugicale*, Paris.

[4] *Medical Enquiries upon Diseases of the Mind*, pp. 35, 199, vol. i.

[5] *Recherches sur differens Points de Physiologie, de Pathologie, et de Thérapeutique*, pp. 353, 354.

permissible. To this there are some proper but comparatively rare exceptions, as is intimated in the close of the preceding paragraph. This exceptional operation must not be undertaken without the understanding of the train of misfortunes that may follow as sequences. Thus, the premature extraction of a deciduous lateral incisor removes a powerful factor in the expansion of the anterior portion of the arch of the jaw, which normally is augmented by the wedging of the permanent central incisors between that tooth and the one of the opposite side. The operation likewise may even tend to produce the effect of a contraction of the jaw by the shrivelling of the cicatricial tissue, which will be more marked in proportion to the greater amount of the same and the longer time it is formed previous to the eruption of the permanent tooth or teeth. Next must be considered the probability of the

Fig. 257.

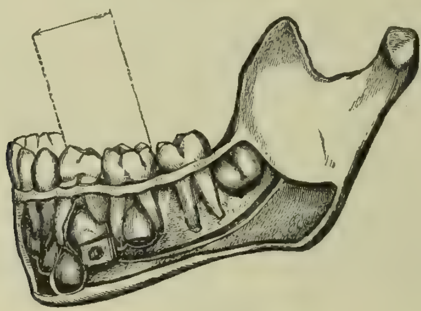
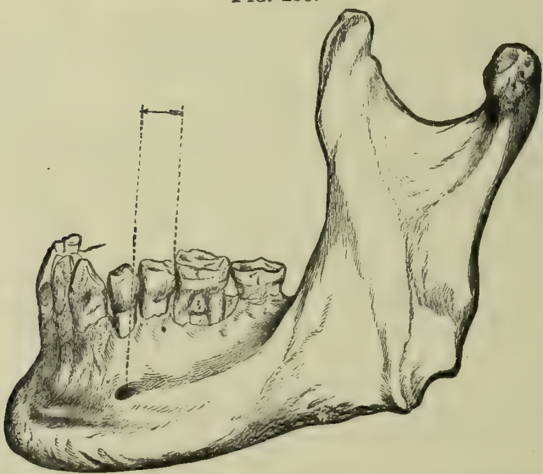


Fig. 258.



Figs. 257 and 258 show, when compared, the usual advance of the first permanent molars after the shedding of the temporary molars, and that no room is afforded to the teeth anterior to the first molars by the difference in size between the temporary molars and the bicuspids. (After Coleman.)

necessity of extracting the deciduous canine to allow the permanent lateral to present normally; and finally the extraction of the permanent first bicuspid to admit the permanent canine, for there is a loss rather

than gain of space between the first permanent molar and canine. (See Figs. 257, 258.) Thus, a chain of unfortunate sequences follows after the first operation, to which they are remotely but partially due, and which must never be undertaken without the determination to meet this possibility and combat it or accept it as the lesser evil.

It is, however, believed by some dentists that the expansion of the jaw is due to its regular developmental force, and that the teeth play no particular part in it. The great mass of observers, however, see a mechanical problem in the wedging of the teeth into the arch. The soft material that develops into the lower jaw is a parallel case, as it seems to be held in shape by the elastic cartilage of Meckel, which appears to play the part of a spring for keeping it in shape.

Preparation for the Operation of Extraction.

The extraction of a tooth having been determined upon, the next thing to be regarded is the rule of Mr. Tomes, Sr., that "the whole of the tooth should be removed with as little injury as possible to the surrounding structures and the least pain necessary to the case." To accomplish this, one must never lose sight of the principal object of the above proposition: "The whole of the tooth should be removed." It is rare indeed that any portion of a tooth may be allowed to remain, although there are some few cases where the broken end of a root may be regarded as an exception, when its extraction would be painful, and Nature may be trusted to bring it to the surface and throw it off. The practice should be to take such precautions in operating, and to be so thorough and deliberate (a guide for which is never to move the forceps faster than the eye can follow them), as to prevent the accident of breaking the teeth.

It is not true kindness to be so tender of heart as to make the patient timid, or to hesitate in the performance of a duty which is designed for his eventual relief from pain. There may be a few moments of torture, but the attention of all—patient, operator, and friends—must be fixed upon the benefit to follow. The sufferer having applied for a specific purpose, it is useless to try to gain his confidence by false representations that the affair will not be painful. It is rare, however, that the anticipation is not greater than the actual pain—sometimes a happy suggestion for the patient. Many are likewise encouraged by the assurance that the first efforts at loosening the teeth are made slowly and are bearable, as they resemble the pain of slow pinching: this is followed quickly by a numbness of the parts, which may be taken advantage of to complete the extraction and assure a comparatively painless finish to the operation. It is like a dull, heavy blow that for a short time produces a local anæsthesia: when the pressure becomes unbearable, upon the patient giving a preconcerted signal the procedure can be arrested at any moment. By strict adherence to this compact by the operator, and by obedience to the patient's wish, his confidence may be gained. Numbers of children have in this way had two or three bicuspids or molars extracted at one and the same sitting. The author believes that cowardice or courage may be cultivated, and

there are few indeed who do not take a pride in acquiring the latter trait, so universally is it admired.

The Position of the Patient's Head.—The head should be firmly fixed, and absolutely under the control of the operator. This can be accomplished in several ways, and since the appliances of dental chairs, head-rests, and other appurtenances may not be at hand, the operator may be compelled to adopt very primitive means as substitutes for them.

Position of Patient for Extraction of Upper Teeth.—The patient may be seated upon a low chair or ordinary stool, upon which or on another stool just behind the first, the operator places his left foot, so that the inside of that leg serves as a chair-back and the knee as the head-support. In this position, if the patient will grasp the sides of the seat, draw down his shoulders, throw his head well back, bracing it over the operator's knee for the head-rest, it is astonishing how little one will miss the costly dental chair. The head of the patient may be firmly pressed against the head-rest by seizing the gum about the tooth with the left forefinger and thumb, the outside of the palm of the hand at times serving to add greatly to the solidity by distributing the pressure upon other parts, as the malar processes, etc.

The Position for Extraction of Lower Teeth.—For the incisors the operator stands behind the patient, who is seated as before with his head against the region of the breast-bone or stomach of the operator. In all cases with a right-handed manipulator this member is used to grasp the extracting instrument, and the left hand, assisted by the left arm and side of his body, is used to secure the patient's head in a firm and immovable position. The forefinger and thumb, aided by the rest of the hand, secure the jaw, grasping the alveolar process where it encircles the neck and roots of the tooth.

In operating upon the lower molar teeth the jaw may be seized with the palm of the left hand next the body of the bone or the cheek, and if the tooth is upon the left side the patient's head embraced by the arm and forearm, holding it against the operator's left side. If the tooth is upon the right side, the dentist stands to the front and facing the patient, whose head may be held immovable against the rest by the left hand, with the palm on the side of the body of the bone, and the forefinger and thumb, with their ends directed backward toward the ear and fauces, clasping the alveolar process. Occasionally with right lower bicuspidati and molars the left thumb draws down the lip while the fingers steady the jaw. The thumb and first finger of the left hand not only play an important part in securing the patient's head, but likewise serve as guards to prevent the injury or wounding of the interior of the mouth by the slipping of the instrument's grasp; they also warn the operator when the alveolar walls are expanding under the pressure upon the tooth.

With some patients it may be rather out of place, and of course with some absolutely and entirely inadmissible, but it has more than once served a very valuable purpose at a critical moment, for the operator to throw his right leg over the patient's right arm or both arms at the elbows, and thus hold down the hands, which if thrown up may strike

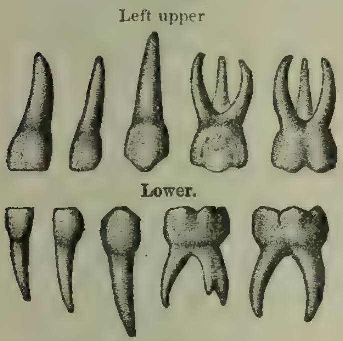
the operator's hand and cause a fracture of the tooth or jaw or some other untoward accident.

Finally, the dentist must not forget the responsibility of his position, but carefully watch that no patient be permitted, while under the excitement of the operation or stimulus of an anæsthetic, to get out of the chair, to the possible injury of himself, the operator, or others who may be present. A little confidence and firmness may be all that are necessary; but if not, then throwing either arm around the back of the head-rest and in front of the patient's throat will give control of the obstreperous by force—the left arm is generally preferred, since that allows the operator's right hand to be free.

A somewhat dangerously excitable patient, who claimed to have knocked down the last dentist who had extracted a tooth for him, was given a practical illustration of this hold upon him; and the utterly helpless condition he found himself in, or some other cause depending upon it, transformed him into one of the most suave, obedient, and respectful in the writer's clientele.

Next in order will be an intimate understanding of the anatomy and relations of the parts, which it is unnecessary here to repeat, the reader being referred to the leading article by Dr. Cryer in the first volume of

Fig. 259.

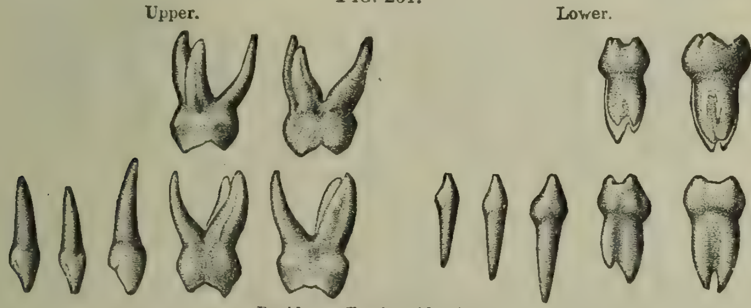


Deciduous Teeth: Front view.

Fig. 260.

Deciduous Teeth: Back view.

Fig. 261.

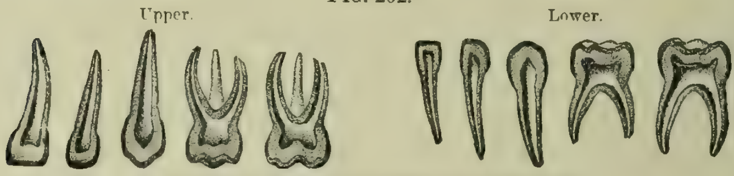


Deciduous Teeth: Side views.

this work. To familiarize the student with the appearance of the roots, crowns, and necks of the teeth he is referred for normal roots to Figs. 259–268, and for the abnormal-shaped roots to Plates I., II., and III.

at the end of this paper. From these it will be seen that the incisors are ovoid in transverse section at their necks (Figs. 265–269), the labial part being the larger, and the antero-posterior or labio-palatal diameter being the longer. The central incisors of the upper jaw and

FIG. 262.

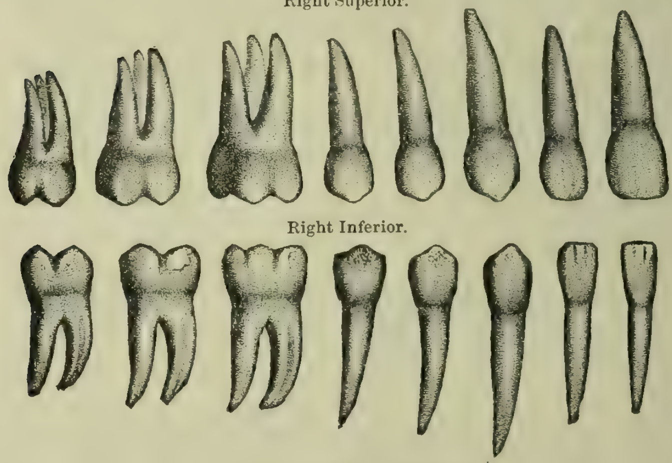


Deciduous Teeth: Views showing the pulp-cavities.

FIG. 263.

Deciduous Teeth: Views showing the pulp-cavities from the side.

FIG. 264.



Permanent Teeth: Front view.

the laterals of the lower are the larger. The roots of the superior central incisors are almost true cones, but those of all the rest of the teeth are more or less compressed, often taking the form of a groove, excepting the upper molars, which vary considerably on the proximate side. The occurrence of these shapes limits or modifies the rotary

motion that is generally spoken of as the first to be used in loosening incisor teeth.

The roots of all the teeth, as a rule, incline backward or away from the median line (Figs. 259, 260, 262, and 264), and the superior laterals often terminate by a more or less abrupt curve, or even an angular point.

The wisdom teeth particularly have an outward as well as a backward curve of the roots (Figs. 264, 265, and 266), which double curve must be borne in mind in all operations upon them involving the roots.

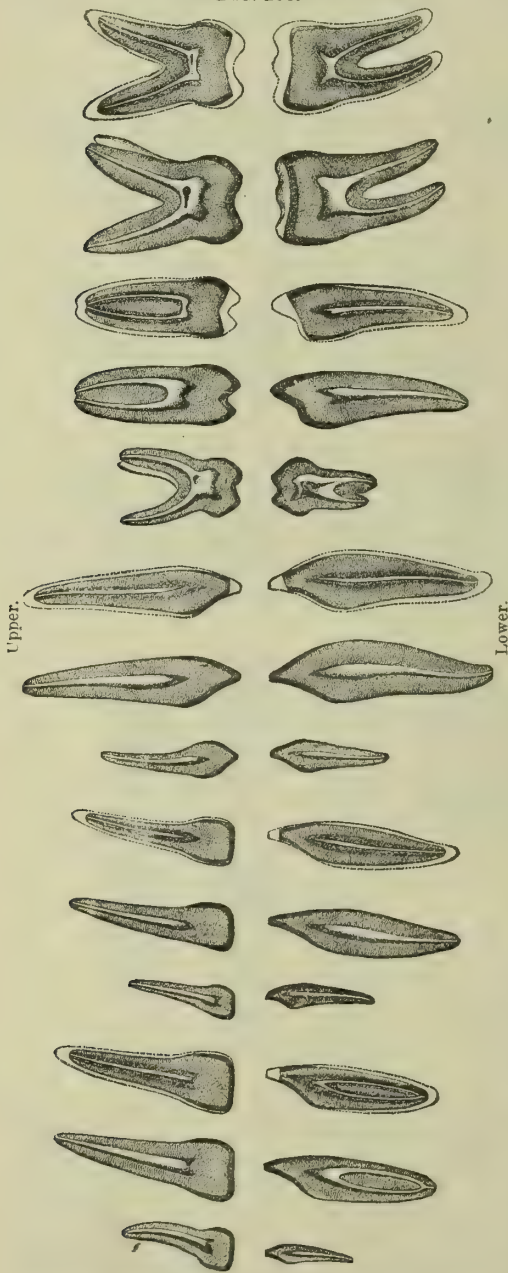
FIG. 265.

Sections of Permanent Teeth, showing pulp-cavities from the proximate or side view.

The hooks formed by these curves make it impossible to remove teeth so crooked without following the curved line of the axis of each individual produced beyond the tooth, upon the same principle that a similarly curved hook would be lifted from its position only by being unhooked. To attempt to remove such teeth in any other way would necessitate fracture either of the bones or the teeth—an easy matter, since both are comparatively frail. For this reason a peculiar application of the force in extracting these teeth is needed, and often also a forceps

(Fig. 289) upon a different principle from the ordinary one, acting as a double wedge to pry the teeth backward. (See description, p. 426.)

Fig. 266.



Sections of the Permanent and Deciduous Teeth, showing pulp-cavities.

To judge of the roots by the appearance of the crowns is not a very difficult task, as the latter show certain marked resemblances of general shape and contour; thus, short, broad, flat teeth, not made so from wear, indicate similar forms of roots; and the slender or tapering teeth are upon correspondingly long and slender roots. Where the crowns are grooved longitudinally or the cusps very pronouncedly independent, they indicate roots that are much grooved and tending to bifurcation. The compact, well-fused, or cylindrical tooth shows the same tendency to union of the roots. Isolated teeth and those that are much worn down by reason of heavy use (Fig. 266) not unfrequently show well-grown if not hypertrophied roots; on the contrary, unworn edges often indicate uncompleted apices of the roots (Fig. 267).

To understand fully these propositions it is probably well to look at the history of the development of the teeth, which can best be understood when each cusp is considered as a separate member of a tooth, having generally a share in the formation of the whole tooth in proportion to the individuality of development and growth of that part. Thus the incisors seem to be formed

from three or four closely-fused double cones (Fig. 267); the canines from four; the middle anterior or labial, much the larger; the palatal, more pronounced, as the cingulum more nearly approaches the form of a separate cusp. The bicuspids plainly show the somewhat slight fusion of the outer and inner halves or elements of the tooth (Figs. 265, 266, 268, and 269). The superior first and second molars by the fusion of their palatal cusps indicate the same of the roots (Figs. 268, 269), while the union of those of the third molars points to the whole of their roots being intimately joined. The lower molars

Fig. 267.

Showing the Serrated Edges of the Unworn Incisor and Cuspid Teeth.

(Figs. 265, 266, and 269) are furnished with anterior or mesial and posterior or distal roots; they seem to be formed by the union of the two anterior elements for one and the two posterior for the other roots. The inferior first molar's anterior or mesial root often presents two distinct canals for the pulp (Figs. 265 and 269), which, like the bicuspids of the upper jaw, may be independent or united only by a slight fissure-like space; the whole showing a very remarkable disposition to bifurcation that need be carried but little farther to effect the division of the root at the median line into two. We sometimes find three or even four roots to these teeth.

The bicuspids of the lower jaw frequently incline inward, and the crowns are often at an obtuse angle with the root (Fig. 265), which will deceive one in attempting the extraction, since they seemingly require to be carried inward more than the root really warrants. These teeth are likewise commonly the ones affected by the crowded condition spoken of when the eruption of the cuspids was under consideration in the earlier portion of this article. The roots of the inferior incisors are often very slight at their apical terminations, and the upper first bicuspids are generally bifurcated; they occasionally terminate in three or even four slight and delicate points. The canines sometimes are bifurcated, which makes them liable to an unhappy accident by their fracture, and to remove these fragments literally necessitates the digging of them out of their sockets. This, however, may often be readily accomplished by passing an ordinary scoop or spoon excavator up under the fragment and drawing it down with the instrument hooked under the piece. For the encouragement of the novice he may remember that such cases are often less difficult than he would suppose, as the pieces generally are loosened by the attempt at extraction by the forceps.

The Operation for Extraction of Teeth.

The first active step in the operation should be a careful examination of the tooth, testing the pressure required to move it, and thus to obtain data from which to form some judgment as to the shape or size of its roots. Many teeth have been removed by the dentist's skilful fingers covered and protected from slipping by a few folds of a napkin or linen or muslin cloth. The Japanese dentists are said to have remarkable skill, which comes of practice in pulling with their fingers pegs of hard wood out of softer pieces into which they have been driven, the object of course being to avoid instrumentation.

Elevators are likewise of great service in some cases during the examination, but the consideration of these will be deferred until after the forceps are spoken of.

Solid, well-worn teeth deeply set in heavy alveolar processes are probably not often extracted by the mode above described, and indeed they fortunately rarely need to be. A tooth standing alone in the jaw, particularly if it has antagonists, seems to be more firmly set in its socket, and not unfrequently the root will be found with the cementum hypertrophied as a sequence of its heavier labor. This latter condition can generally be known by the peculiar resistance to any move for its extraction after it has been most thoroughly loosened. To gradually work such teeth out without fracture requires some patience and much perseverance. Without getting hasty or impetuous the operator slowly drags it out with a rolling or prying motion from side to side.

The converse, however, is true, and teeth without antagonists become very loose, even although they may have at one time been very firmly set in the jaws. Many of those presenting the most formidable appearance after extraction have been very easily removed, as the process of investing bone had either been absorbed or was spongy or very slight and springy.

The peculiarities of spreading or bifurcating roots can be to a certain extent diagnosticated by the appearance of the crowns, as before mentioned, and the thorough study and understanding of the different stages of development and the track through which the tooth has passed from its enveloping sac to its position in the jaw. This knowledge of course will be very valuable in cases of crowded arches, as it will give some idea of the direction in which the root may be expected to curve; which condition we find frequently accompanying irregularity of the teeth.

The operation is divided into three stages:

1st, seizing the tooth;

2d, loosening and breaking up its attachments;

3d, extraction or removal.

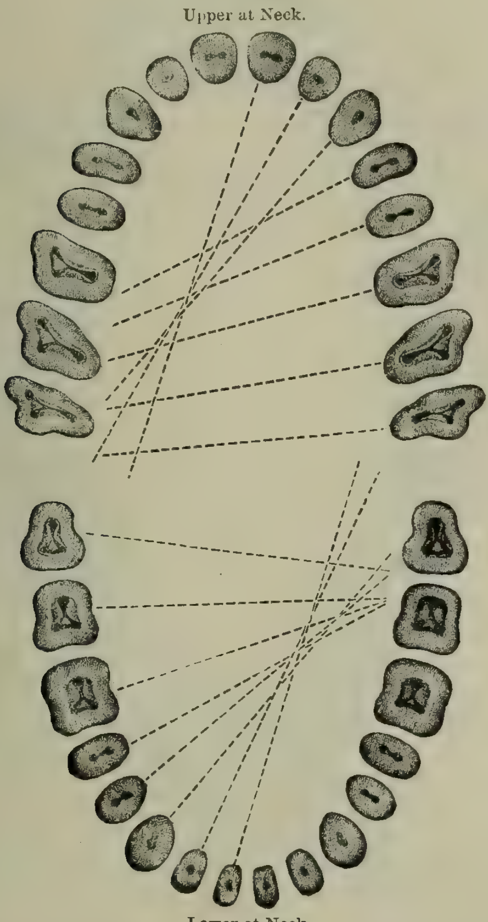
After examination of the tooth and selection of the instruments to be used, the latter should be quietly laid near at hand, but under the cover of a clean napkin.

Each one of the three stages of the operation should be completed before proceeding to the next; and in this, as before mentioned, the

whole attention of the extractor should be devoted to the accomplishment of that one exclusively.

1st. *Seizing the tooth* should be performed by placing the beaks of the forceps as far up on the root as possible, unless it be very loose. Generally, the upper part of the neck of the tooth is the best part at which to take hold. Oftentimes the effort required to put the beaks up is very considerable, and one celebrated teacher's advice was to push the forceps as if the operator designed to pierce the jaw and have the beaks come out at the top of the head or the under side of the chin. Some-

Fig. 268.



Transverse Sections of the Permanent Teeth. The dotted lines represent the direction of the movement for loosening the teeth.

times a slight rotary movement greatly assists the accomplishment of this part of the operation, the beaks seeming to bore their way.

The gums being acutely sensitive to crushing or pinching, the beaks should be carefully inserted under them and close to the tooth, so as to

be guided by it and to pass between it and the margin of the investing bone, which often is pried away from around the tooth. After the operator is assured that he has the tooth firmly grasped, he may then proceed to the next step.

2d. *Loosening the Tooth.*—This generally is best accomplished by moving it in a line with the long axis of the transverse section of its roots (Figs. 268 and 269). Imagine a centre point at which radii from each tooth

Fig. 269.

Upper.

Lower.

Transverse Section of the Roots of the Permanent Teeth.

would meet like the spokes at the hub of a wheel, and to this it will be found that nearly every such axis tends for the semicircular part of the arch.

The loosening of the upper central incisor should be first attempted by rotation upon its long axis to the right and then to the left, as if twist-

ing it. If it does not become completely loosened in this way, it should then be pressed alternately outward and inward, or backward toward the throat. The lateral incisors may be pressed in a line at a slight angle to this one—say, toward the tonsils of the opposite side—the canine toward the third molars, and the bicuspids and molars to the back of the molars on the opposite side of the mouth. With the lower teeth the compressed roots of the incisors rarely admit of the rotary or twist-

FIG. 270.

A View of the Alveoli.

ing motion, as likewise may be said of the superior lateral if hooked at the end: these teeth will often break before they will loosen by this movement.

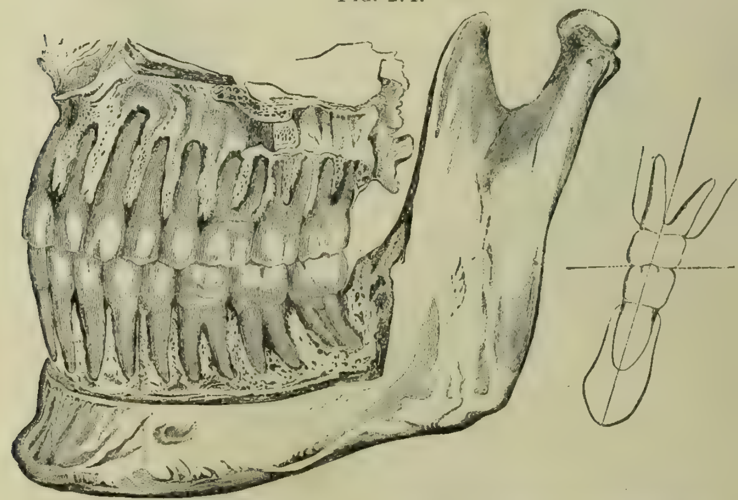
The movement of the teeth should first be attempted toward the weakest or slightest part of the investing alveolar process, which is generally outward in the upper jaw, as the outer plate of alveolar process is the slighter, and in the lower jaw it may be in some cases inward; but if the teeth are crowded it is best generally not to press them toward the centre of the arch, as they may fracture adjoining

ones. These movements must be persevered with until the tooth is quite loose and seems almost ready to drop out of its own accord. By the time this is accomplished the whole surroundings have generally become so benumbed as to admit the removal of the tooth without pain. Indeed, it is the practice of this slow movement and stopping each time the patient wishes a moment's relief that has made the small amount of pain suffered by the patient often a matter of the most agreeable surprise. Remembrance of this cannot be too much urged upon the operator who would succeed as an extractor of teeth: it is the greatest means of extracting without pain, the safest local anæsthetic.

The teeth may be slowly loosened, and with infliction of little pain, by putting elastic rubber rings up around their necks for several days until the investing bone is absorbed. The attempt at loosening with the forceps will often bring the same condition about after several days' waiting.

3d. *The Removal of the Tooth* must be commenced slowly, and pressure gradually be put upon it to draw it from its socket, feeling carefully for the direction in which it most readily yields, and avoiding if possible the exertion of so much force as in the sudden release of the tooth would cause a jar or jerk. Such mishaps as the latter may be guarded against in some cases by letting go of the alveolar process with the left hand after the tooth has been nearly extracted, and placing the

FIG. 271.



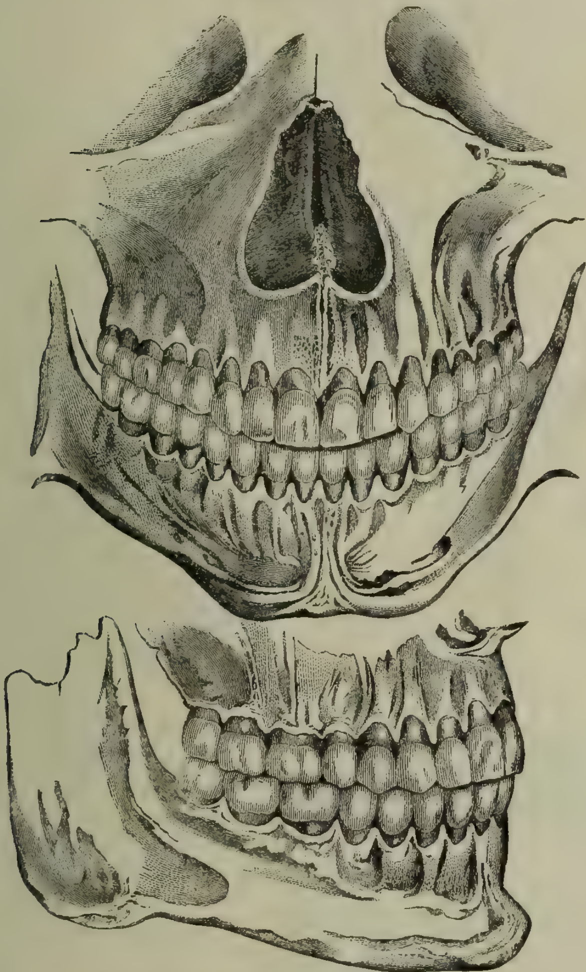
View of Teeth *in situ*, with the External Plates of the Alveolar Processes Removed.

fingers of that hand to guard the teeth of the opposite jaw or parts threatened with a blow from the forceps when the tooth comes away with a sudden jerk.

If every move is slowly and cautiously made until the tooth is perfectly loose, it is not so difficult an operation as generally it is supposed to be. There are, however, cases where the operation is one of the most difficult in surgery. The beaks should be slowly closed upon the tooth,

and no movement made faster than the eye can readily follow. The operator should be intent only upon what he is doing, and the sense of touch communicated to the hand by the instrument must be exquisitely cultivated. In fact, the successful extractor becomes for the time being an animated right hand by ablation of all thought of the rest of his body. By the concentration of this attention to the member performing the operation this state, approaching that which the Hindoo or

FIG. 272.



Front and Side Views of the Teeth and Jaws.

Brahman claims to attain, can be quickly acquired. The patient's cries fall upon ears that are deaf for the time being, and the tears and pleading looks never at this critical moment should penetrate to the dentist's consciousness. The operation completed, the time for consolation, display of a kindly and sympathetic heart, is opportune, and in no way

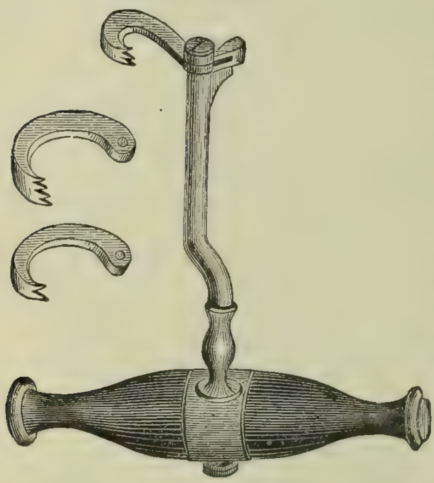
disadvantageous. But it must never be forgotten by the surgeon that what he does is for the patient's welfare, and "If it were done when 'tis done, then 'twere well it were done quickly."

The Extracting Instruments.

The selection of suitable instruments for extracting the teeth is one of the principal steps toward success. An ill-shaped, unserviceable instrument, serving often to fracture the tooth rather than to extract it, will soon cause the novice to lose confidence in himself as well as to produce the same feeling among his patients. To be able to remove a tooth with the rudest implement may be a good qualification, but nothing short of a pressing necessity and an Arctic or desert expedition should be an excuse for such butchery. It is neither economical, wise, nor humane to attempt to extract teeth with a defective or partial armamentarium; therefore a thorough and complete set of extracting instruments will be named, designating them in the order of their fitness for general use or comparative value.

Some five or seven forceps are sufficient for 90 to 95 per cent. of the operations, but when one wants a certain modification for an urgent case, the value of that one is hardly to be estimated in money.

Fig. 273.



Key Instrument for Extracting Teeth. The upper portion represents, on the right hand, the bolster or fulcrum, and on the left hand a claw which revolves upon a screw shown at quite the extremity. The steel bar which connects this portion with the handle is bent, so as to permit it to clear the front teeth. The detached claws represent different widths for application to larger or smaller teeth.

The key of Garengeot (Fig. 273) was at one time all that was considered necessary for extracting. An extra claw or two sometimes was added, and a lancet which sufficed to draw blood enough to hide from view the brutal crushing of the gum and alveolar process by the bolster or fulcrum. With this vest-pocket edition the so-called dentist sallied forth to wring from the world his livelihood. Is it any wonder that he was abhorred as an attaché of the Inquisition, and the name of dentist even yet among the untutored begets a cold shudder? This instrument for many years was the only one in use for extracting teeth, and a red silk handkerchief wrapped around the fulcrum was supposed to show the consideration of the dentist in keeping the steel from injuring the gum.

There is, however, a method of applying the fulcrum to one side of the tooth, and hooking the claw over into the other side, so as to grasp it, that may serve to make the work less cruel. But very rarely can

FIG. 274.

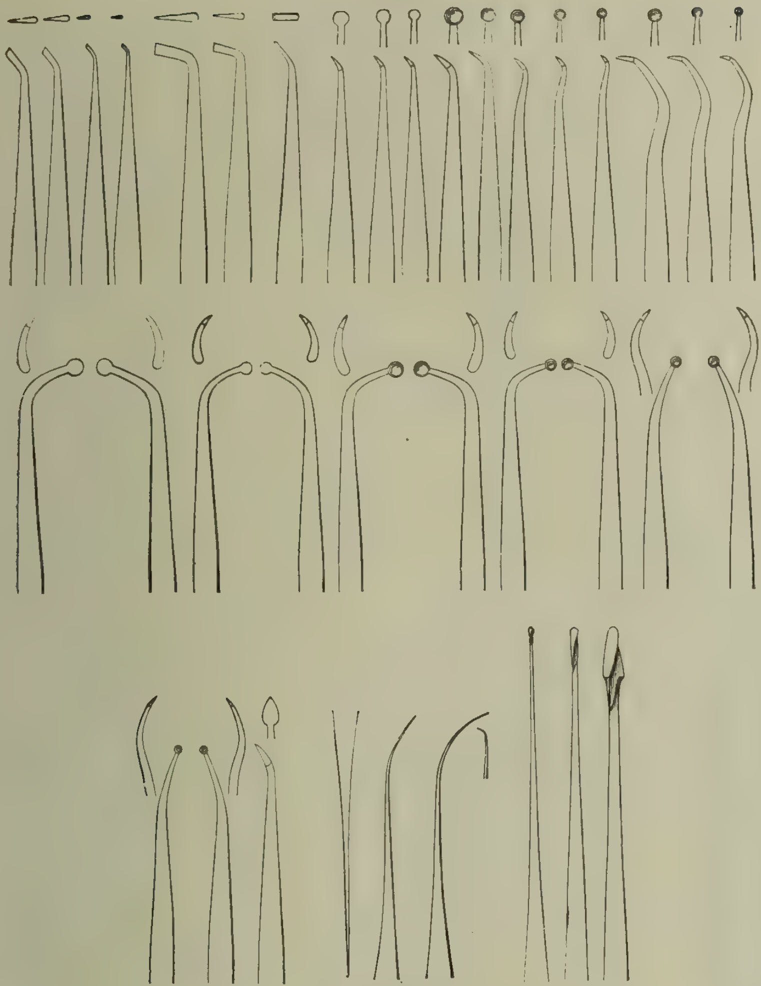
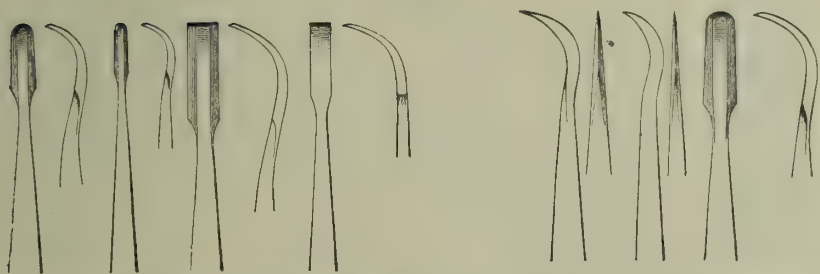


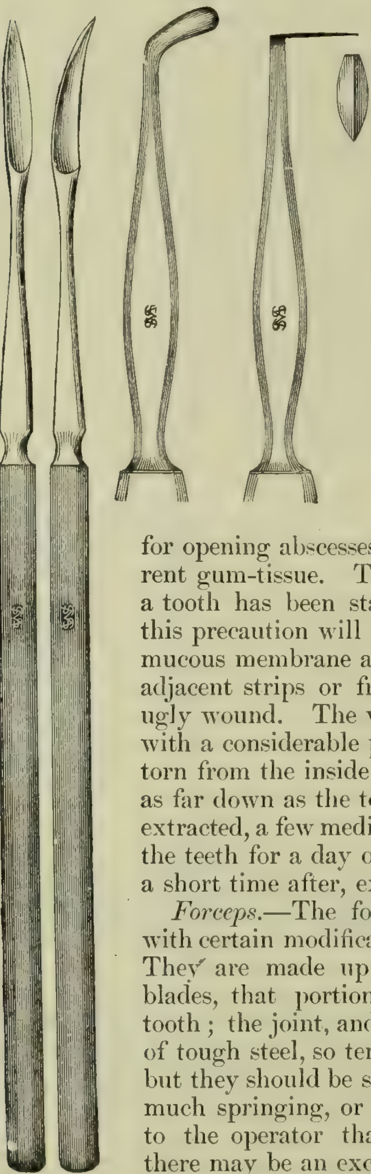
FIG. 275.



there be found a case where the key exerts its force in the axial line of the tooth, and in a vast majority it requires so much undue force in its

use that the instrument may be said to be practically abandoned. By alternate movements to either side, after it is adjusted as described above, it is claimed that the tooth may be so loosened as to permit it to be lifted up. But this latter movement is made at the short end of the lever, and will require more strength of wrist than is needed with the forceps which are at the present day nearly universally adopted.

Fig. 276.



The extracting case should be furnished with a few ordinary excavating instruments (Figs. 274, 275) for exploring cavities, particularly the pulp-chambers of the teeth; a mouth-mirror or two for the examination of the back part of the mouth and teeth; drills for entering the pulp-chambers, or enlarging this cavity to admit the screw for extraction and remove débris, that often accumulates until the forcing up of the screw is made unnecessarily painful by driving that matter before it; lancets (Fig. 276) for opening abscesses and others for separating the adherent gum-tissue. The latter particularly is needed where a tooth has been standing alone, as sometimes neglect of this precaution will cause the stripping off of some of the mucous membrane attached to the tooth, which may bring adjacent strips or fragments with it and inflict quite an ugly wound. The wisdom teeth often have been removed with a considerable piece of the gum-tissue, which may be torn from the inside of the cheek, or with lower teeth from as far down as the tonsils. As aching teeth should not be extracted, a few medicaments for relieving pain and dressing the teeth for a day or so before, or the alveolar cavities for a short time after, extraction are needed.

Forceps.—The forceps are a pair of pincers or pliers, with certain modifications of shape to suit special purposes. They are made up of three parts—the jaws, beaks, or blades, that portion beyond the joint which seizes the tooth; the joint, and the handles. They should be made of tough steel, so tempered as to spring rather than break, but they should be sufficiently heavy and strong to prevent much springing, or they will convey an uncertain feeling to the operator that may cause an accident. To this there may be an exception made in those forceps designed exclusively for roots, where it is desirable that the upper half or more of the blades shall pass between the root and its investing bony process, with the infliction of as little violence or injury to these

tissues as possible. They likewise need to be tempered sufficiently to keep a sharp edge at the point; many of them are designed to dispense with gum-lancets in extraction, and to separate that tissue from the necks of the teeth. The advantage of the latter form may be seen in the abolishment of the dreaded preparatory step of lancing, for which suffering the patient sees nothing in the way of an advance in the operation, and the operator finds the blood obscuring the view of the parts upon which the forceps are to seize. The beaks are generally hollowed out on the insides or opposing faces, so as to fit accurately upon the necks of typical teeth of the class for which they are designed. At the same time they should allow the crowns of the teeth to be untouched when the necks are held tightly in their grasp.

Upon the adaptation of the beaks the purchaser should always satisfy himself by personally and carefully testing each instrument, although there are but rarely to be found new modern ones that will not answer this requirement. It is so self-evident that the forceps beaks should come in contact with as much of the surface at the neck as possible in order to avoid the crushing or nipping off of the crown that a discussion of the reason may be unnecessary; but a proportionately emphatic and positive insistence upon this requisite may be enjoined. The forceps beaks are slightly roughened, grooved, or barbed inside as a precaution against slipping or turning on the teeth. These roughened surfaces should be of such shapes as to be capable of being readily cleaned, and the entire surface of the instruments, excepting the outsides of the handles, should be highly polished and kept free from rust or anything that might favor the retention of blood or any material that would convey contagious matter. Therefore we now find the most exquisite polish put upon these instruments by the best manufacturers, both as a matter of refined taste and as a highly important sanitary measure.

The joints are quite important, since here is the greatest danger of a fracture. Quite recently a case of a very serious and distressing nature occurred in England, which is reported[1] as having required a somewhat novel and dangerous operation by Sir Wm. MacCormac for the removal of the fractured half of a forceps beak from the right bronchus through an opening in the trachea of the patient.

There should likewise be care in the construction of the joints to prevent their pinching or cutting the lip, tongue, or cheeks.

The American manufacturers make forceps the joints of which interlock, one-half passing through a slot in the other, and the whole held by a rivet passing through the centre. The English, on the contrary, have their forceps blades held by a screw that takes the entire strain, simply holding the two halves side by side at the joint. The latter method gives the advantage of a ready means of thorough cleaning and some slight lateral movement in adjusting the beaks to the sides of the tooth; which, however, we do not consider compensates for the greater weakness of that joint, the consequent want of firmness of the grip, and the danger of fracture when the forceps are under the heavy strain sometimes brought upon this portion.

[1] *The Proceedings of the Odontological Society of Great Britain*, vol. xviii. No. 2, p. 37, Dec. 5, 1885.

In all cases, ornamentation of this joint by finishing in the octagon form or setting jewels in the ends of the rivets, as practised in earlier times, is objectionable, because of the additional danger incurred in their use from cutting or bruising the patient's mouth by the corners of the former or the setting of the latter. The finest instruments, or at least the most expensive ones, are now made with joints the transverse sections of which are rounded or oval.

The handles should be of a size and shape to most comfortably fit the hand of the operator, but they should be as straight as practicable for each tooth, so that there may not be more inclination to either side than the tooth may be found to favor as it is drawn from its socket. The manufacturers appear to entertain an erroneous impression, that a hook upon the end of the handle, turning up over the little finger of the operator, assists him in holding on to or pulling the instrument. A first glance would seem to confirm this, but for practical illustration, if the forceps are suspended by the beaks and a weight be put upon the hook, it will be seen that it tends to deflect from the axis of the instrument—a force which so far from being a help would rather break the tooth or hinder its extraction.

The length of the instrument should be no greater than is required to afford a firm hold upon the tooth and for the hand, the object being to bring the power near to the point of resistance. The opposite to this rule might be true if the patient's head was firmly held by some mechanical contrivance or by an assistant; then such long handles as resemble the blacksmith's tongs might avail in allowing the dentist to seize the forceps with both hands and pull.[1]

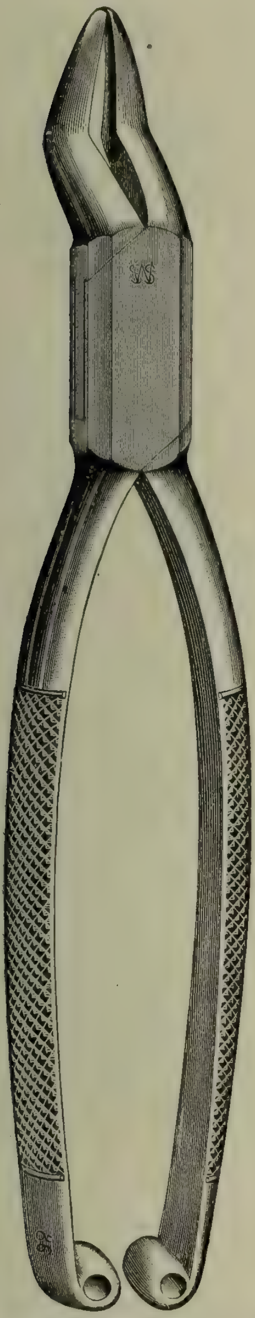
The portion of the handles with which the hand of the operator comes in direct contact when in use should be cut in some pattern to avoid its being made slippery by moisture or by blood. For this checkering or a very coarse file or diamond pattern seems to be preferred. Some years since Dr. Carl Tellander of Stockholm, Sweden, called the writer's attention to a set of curious forceps the handles of which had inside hooks for the forefingers and projections contrived to fit between the other fingers. It remains a question whether these will ever be needed by one who has the strength of hand fitting him for the operation. Such contrivances for holding tools, reins, etc. seem to be very generally discarded by those who make a business of their use, as the resultant cramped position is claimed to be more trying than the exertion they save.

The inner sides of the handles, their edges, and ends should be smooth and highly polished for the sake of greater cleanliness and ease in keeping them bright. This is likewise an advantage if the operator should use the opened forceps as an impromptu tongue-holder, a very satisfactory way being to let the patient hold one-half of the handle of the opened forceps upon his own tongue, and the other in his own hand.

Prof. Henry I. Dorr had constructed forceps (Fig. 277) that were designed for extracting roots, the ends of their handles being enlarged and appearing to be rolled or turned inward toward each other, so that

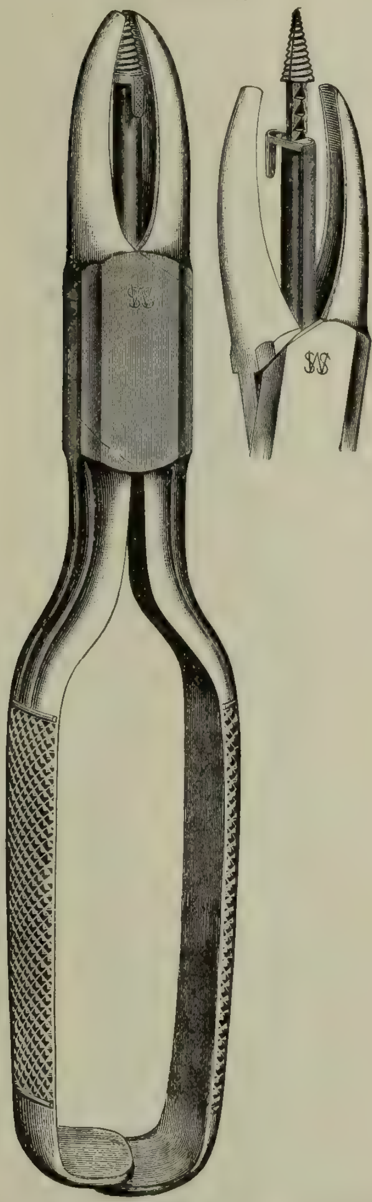
[1] Such forceps are now in the museum of the Philadelphia Dental College, and were once used by a very celebrated operator in New York City.

FIG. 277.



Root, Upper, bayonet shape. The ends of the handles are rounded to fit the palm of the hand, so that the beaks can be easily forced between the tooth and the alveolus. (Designed by Prof. Henry I. Dorr.)

FIG. 278.



Screw Forceps for Upper Incisor Roots. (Designed by Dr. S. P. Hullihen.)

the palm of the hand could exert pressure upon the end of either handle separately or upon both to force the beaks of the instrument up under the bone around the tooth-root. Another method of accomplishing the same may be seen in Fig. 278, representing Dr. S. P. Hullihen's combined root-and-screw forceps.

Finally, all of these instruments are very often nickel-plated. It greatly relieves the care necessary to protect from rust to keep them in close-fitting cases free from moisture. Nickel-plating would seem to make them slippery—an objectionable feature which may, however, be guarded against by a little more precaution in making the diamond cutting on the handles in the right place and of suitable depth and shape.

The forceps that can be put to the greatest number of uses in the extraction of the different teeth are the straight incisor. The figures opposite represent the two most useful. The first, or Fig. 279, should have the beaks fashioned like those shown in the wood-cut, which are intended for the usual adult central incisors, cuspids, and bicuspids. The other (Fig. 280) is designed for adult lateral incisors and roots or for deciduous teeth.

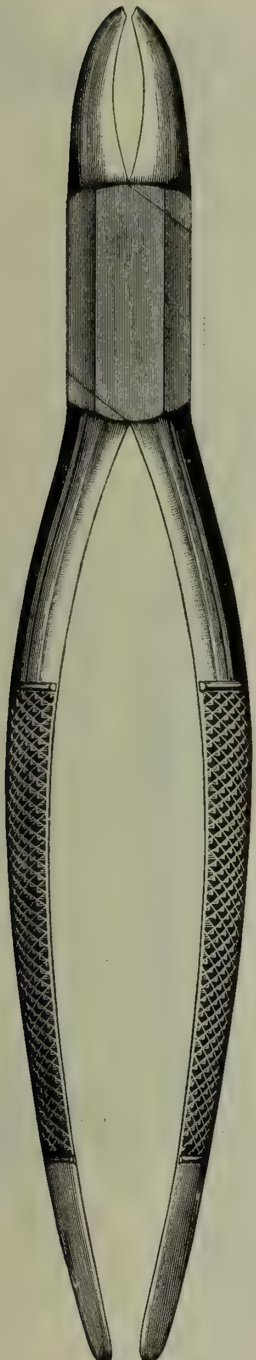
These same straight forceps possess the great advantage that their axes are directly in a line with the force to be exerted. Molars, particularly the roots, are often capable of being grasped and extracted by these forceps. In all cases, but most particularly in the classes of teeth other than those for which the forceps are designed, the operator must look to the adaptation of the beaks to the surfaces of each tooth to avoid fracturing. The larger beak should fit the outside, and the smaller for the inner or palatal part of the tooth.

In many mouths these forceps are readily used for the anterior teeth of the lower as well as the upper jaw. To extract the inferior teeth with these forceps requires that the patient's head should be much lower than in most dental operations. To secure this relative position the operator used a platform or stool in the olden time, but now the chairs are so constructed as to be capable of much lower adjustment. Without such a platform or chair it may be necessary to seat the patient upon a stool or even a cushion upon the floor and, as already described, support the head between the knees of the operator seated. This position has the advantage of allowing a freedom of use of both hands, and at the same time the disadvantage of the possible lack of anything for the patient to hold on by and brace himself. As a whole, this posture, however, is very like the barbarous one that the African negro assumes when digging out a tooth by means of a spear-point, and, even if it were highly recommendable, is unlikely to be adopted in polite society.

In view of these difficulties in using for the lower teeth the form of forceps just described, the least expensive and most desirable means is to have forceps curved to suit the operation. Where these teeth incline inward or backward such forceps are indispensable. This form is sometimes very serviceable for the superior as well as the inferior bicuspids or molars, particularly the roots of the latter.[1] Even the upper wisdom teeth, when presenting in an unnatural manner, particularly when the

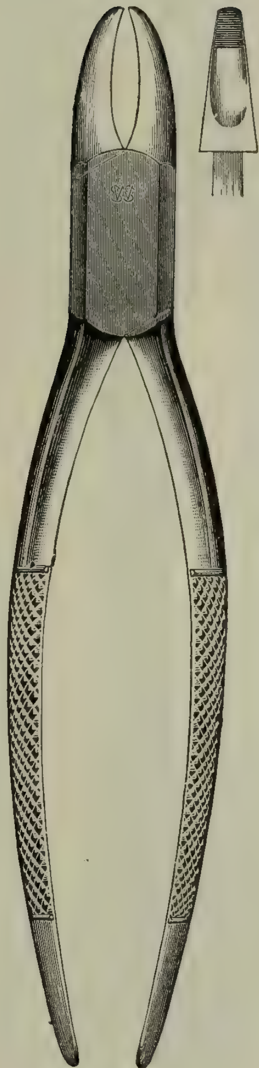
[1] See Figs. 281, 282.

Fig. 279.



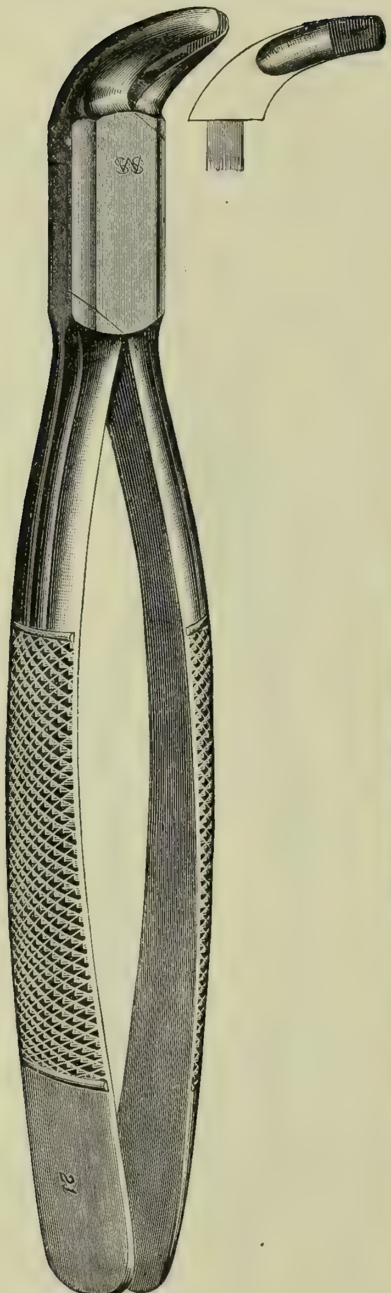
Upper Incisor.

Fig. 280.



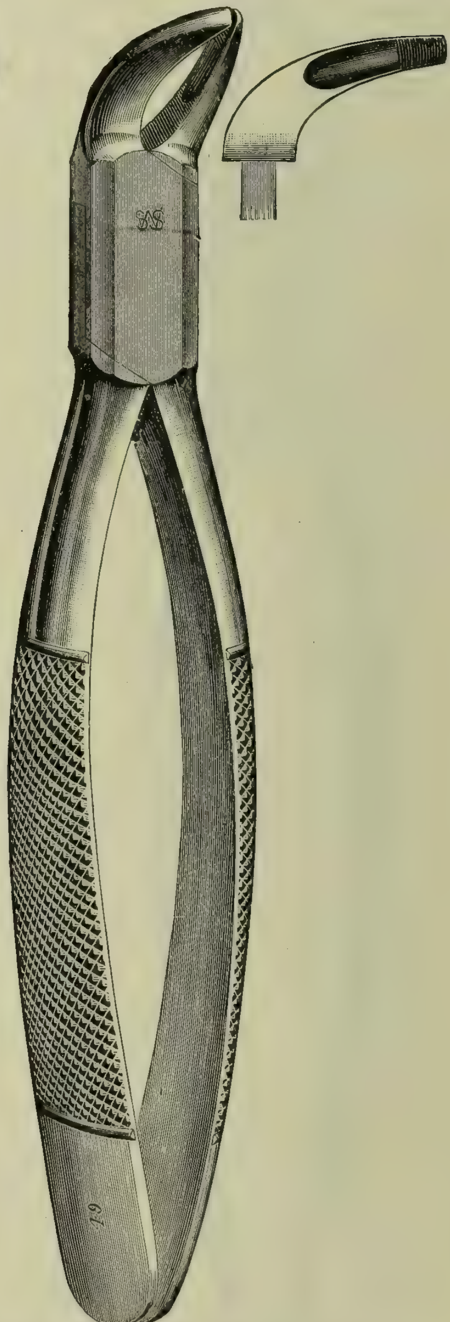
Lateral Incisors, Roots, and Children's Teeth, straight.

Fig. 281.



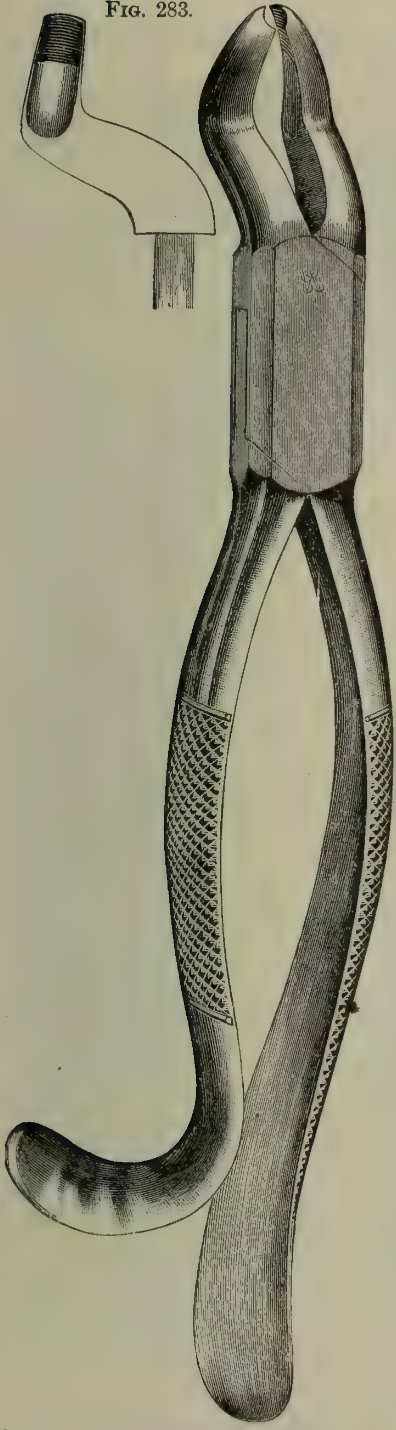
Bicuspid or Cuspid, Lower.

Fig. 282.



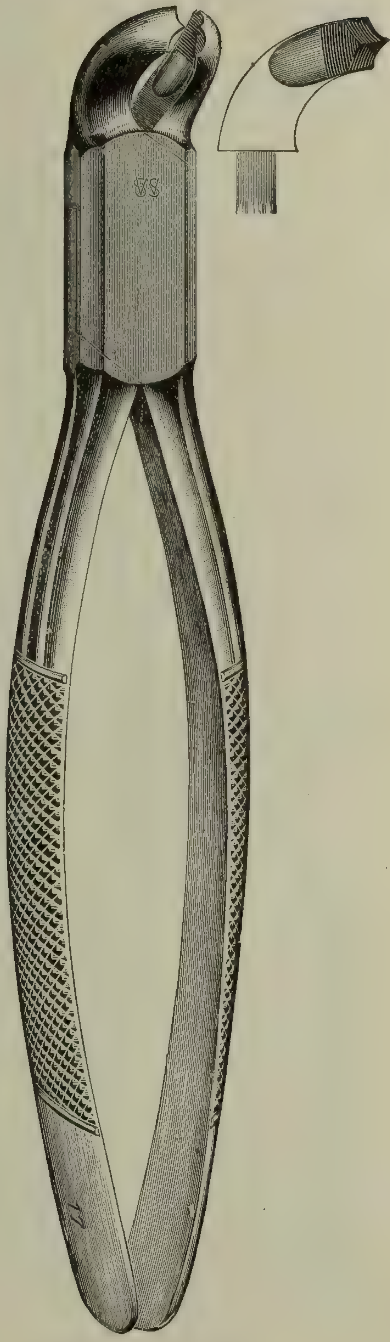
Incisor and Lower Molar--Root, either side. For extracting lower molars with crowns liable to fracture under direct application of the forceps.

Fig. 283.



Dentes Sapientiæ, Upper, either side. Also made with straight handles.

Fig. 284.



Molar, Lower, either side.

masticating faces are toward the cheek, are oftentimes better reached and more easily extracted by this instrument.

The crowded and irregular positions of the anterior teeth being much more common in the lower jaw, the very narrowest beaks are sometimes essential, and under such circumstances the instruments to be mentioned later on as cutting forceps may be useful. English manufacturers make forceps for such irregular teeth in both the upper and lower jaw with one regulation-shaped beak, and the other very narrow, so as to pass between the adjacent teeth to avoid their displacement or injury. It is, however, very infrequent that such operations are demanded as require the use of these instruments, and then it would be best to have them made expressly for each particular case. At the same time, the operation is daily growing more rare since the spread of knowledge of the improvement possible by the ready means at hand for expanding the jaw and wedging the teeth apart. Likewise, the attention paid to the dentition of children generally causes the parent or guardian to be more timely warned and the dentist to see the case before it is so far neglected.

Proceeding backward, the straight instruments must give place to those appropriately curved, to enable the operator to seize the tooth and draw it from its socket in the line of the common axis of the roots. To accomplish this, the so-called bayonet shape is probably the best, and least likely to confuse the novice; for in the third stage of the operation he is with this form merely required to keep his attention fixed intently upon the direction of the axis of the beaks. The pattern here shown is designed expressly for the wisdom teeth, but will often answer for any of the upper molars unless they have much-weakened crowns that compel the dentist to take hold higher up on the roots or between their bifurcations, as designed by the instruments with buccal beaks, of which notice will be taken later on (Figs. 291, 292, and 293).

There seems to be some diversity of opinion as to the best shapes for the instruments for the extraction of lower molar teeth—a matter by no means unusual, some operators preferring the forceps with several curves that are used from the right side of the patient for either side of the mouth, cuts of which will be shown presently. The forceps known as No. 17 (Fig. 284) are so simple in their transmission of the force as to be sufficient for all operations upon lower molars with fairly strong crowns, and indeed often are preferred for the removal of the undivided roots. After placing these upon the tooth, the loosening of the roots is accomplished by a rolling motion to the right and left, which ordinarily only requires a wrist movement, but the whole arm, and even the shoulder, may be brought to bear on it if necessary.

With the half dozen instruments now described, or perhaps the one next to be recommended, substituted for the smaller incisor (Fig. 280), most of the work will be done; and if the design of the dentist is to travel where the bulk and weight of his instruments are serious considerations, involving the possibility of life, then, and only then, can he be justified in attempting with these all operations that may present for extraction.

To be fully equipped other patterns will be needed, and although much less frequently used, still they will prove of inestimable value. This, which may be styled a supplementary list, is larger than the orig-

FIG. 285.

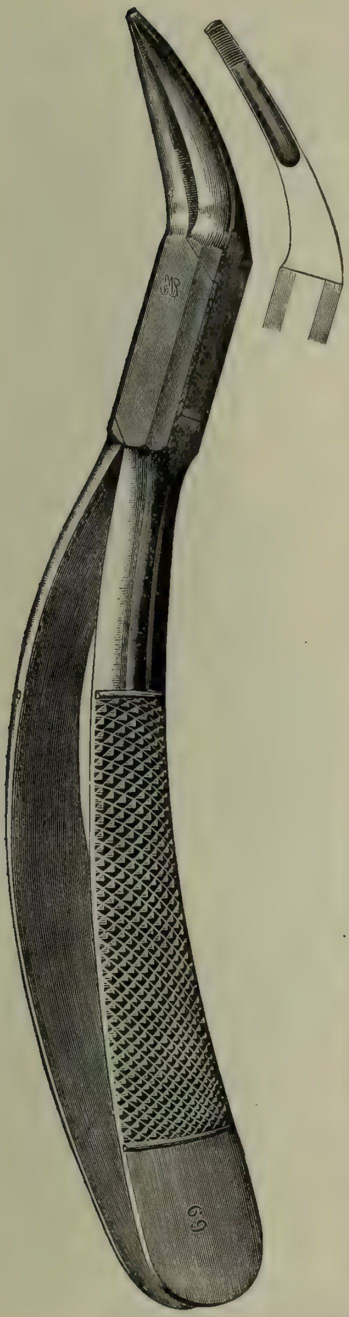


FIG. 286.

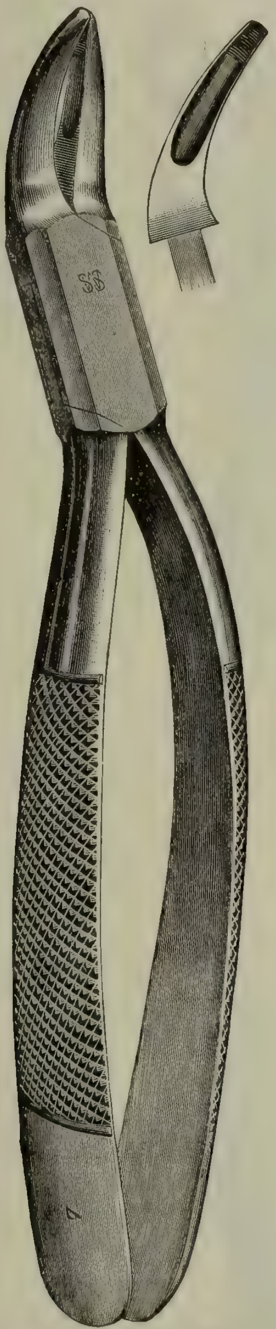
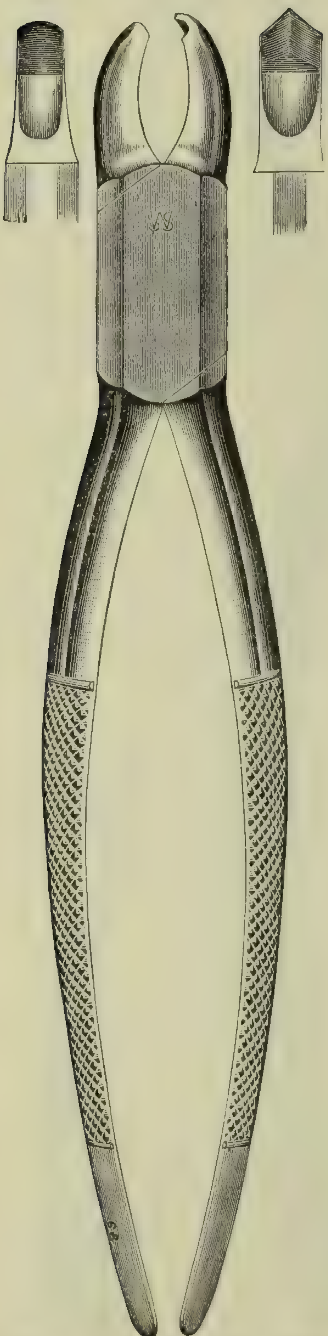


FIG. 287.

Fig. 285. Fragment, or Small Root, universal. (Designed by Mr. Tomes.)
Fig. 286. Root, Upper Back, universal.
Fig. 287. Coleman's Forceps for extracting the roots of upper third molars.

FIG. 288.



Molar, Upper, either side, straight. The buccal beak constructed to fit the depression between the buccal roots.

inal, and it is likely that most young men entering the profession to-day who provide themselves with these selections will find themselves prepared for all the operations of a lifetime.

Supplementary List.—The three forms of root-forceps shown here (Figs. 285, 286, 287) are all so good as to leave little to choose between them, so that any one will answer the purposes designed. These numbers likewise may be used for irregular teeth, for incisor roots, and about the mouth generally.

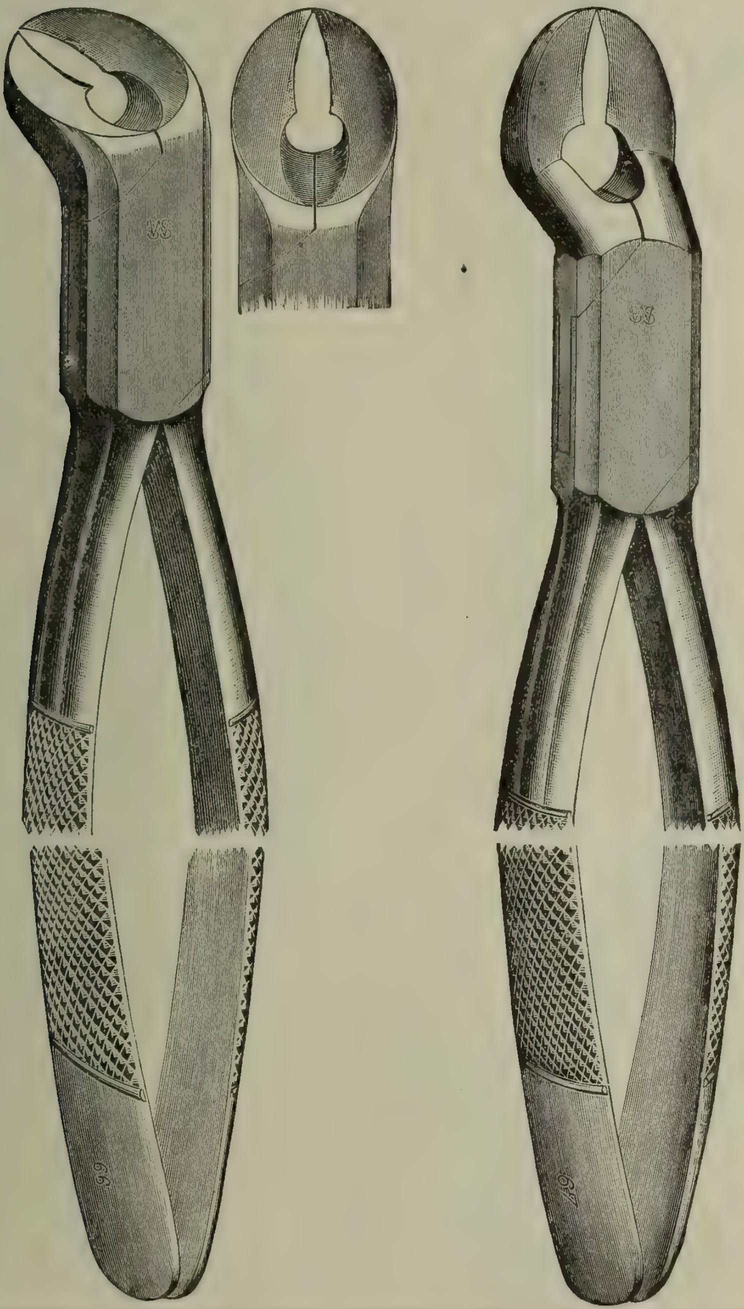
Many patterns have been designed for the upper molar teeth; of these, the first are generally so well toward the front of the mouth as to make a perfectly straight instrument (Fig. 288) available, and equally useful for either the right or left side, thus saving the delay consequent upon the change of forceps when operating—a most important consideration where time is precious, as is the case if the patient be a child or timid or in the anæsthetic state from nitrous oxide, which is so evanescent in its effects.

The two pairs of cutting forceps shown in Fig. 289, next page, are specially designed, the first for the lower and the second for the upper teeth. The early diagrams and most of the instruments have the fault that the edges of the blades are straight instead of incurved, so as to cut through the gum and bone first at the apex, and then gradually close over the root toward the crown end, thus avoiding the danger of splitting the root or the jaw. This very important modification may be made by grinding those made after the older patterns. The advantage of their double curved blades is the tendency of the force they exert on being closed over the root to lift it from its socket, also the cutting of the bone completely down to the root, so as to free it entirely. They are designed to separate the roots of teeth where they are so hooked or curved or spread as to compel their separate removal or the fracture of the bone. The extraction of badly-exostosed roots when encircled by heavy

bone is almost impossible without fracture or cutting, and these forceps

FIG. 289.

Lower. Upper.



Combined Root, Incising, Separating, Splitting, Elevating, and Wisdom Teeth. (Designed by the writer.)

do the latter without removing masses of the alveolar walls, as the ordinary double-edged alveolar forceps do. Thus they avoid that crushing and loss of a large amount of gum-tissue and bone which often so materially interferes with the adjustment and comfortable wearing of artificial teeth, and always leaves, instead of a simple clean cut to heal by first intention, an extensive wound to be filled by the slower process of granulation, thus for a long time subjecting the patient to pain in the performance of the act of mastication.

The removal of some wisdom teeth can be accomplished only by pressing them outward and backward as well as upward in the lower jaw or downward in the upper jaw. To accomplish this, the forceps said to have been designed by Dr. Physick of Philadelphia were formerly used, but now these patterns very generally accomplish the same purpose. For the latter use their jaws are double inclined planes, and are wedged between the third molar and the one in front of it, and then the former is pried in the direction required. The tooth used as a fulcrum has to be supported by the one next in front, and in the case of a gap between these, by reason of the loss of a tooth or other cause, the space must be temporarily filled by a piece of wood, vulcanite, or celluloid, which must be wedged firmly between it and the next tooth toward the front. By pressure backward the extractor may greatly relieve the force upon the fulcrum. Precaution must be taken that the wisdom tooth is not swallowed or drawn down into the air-passages.

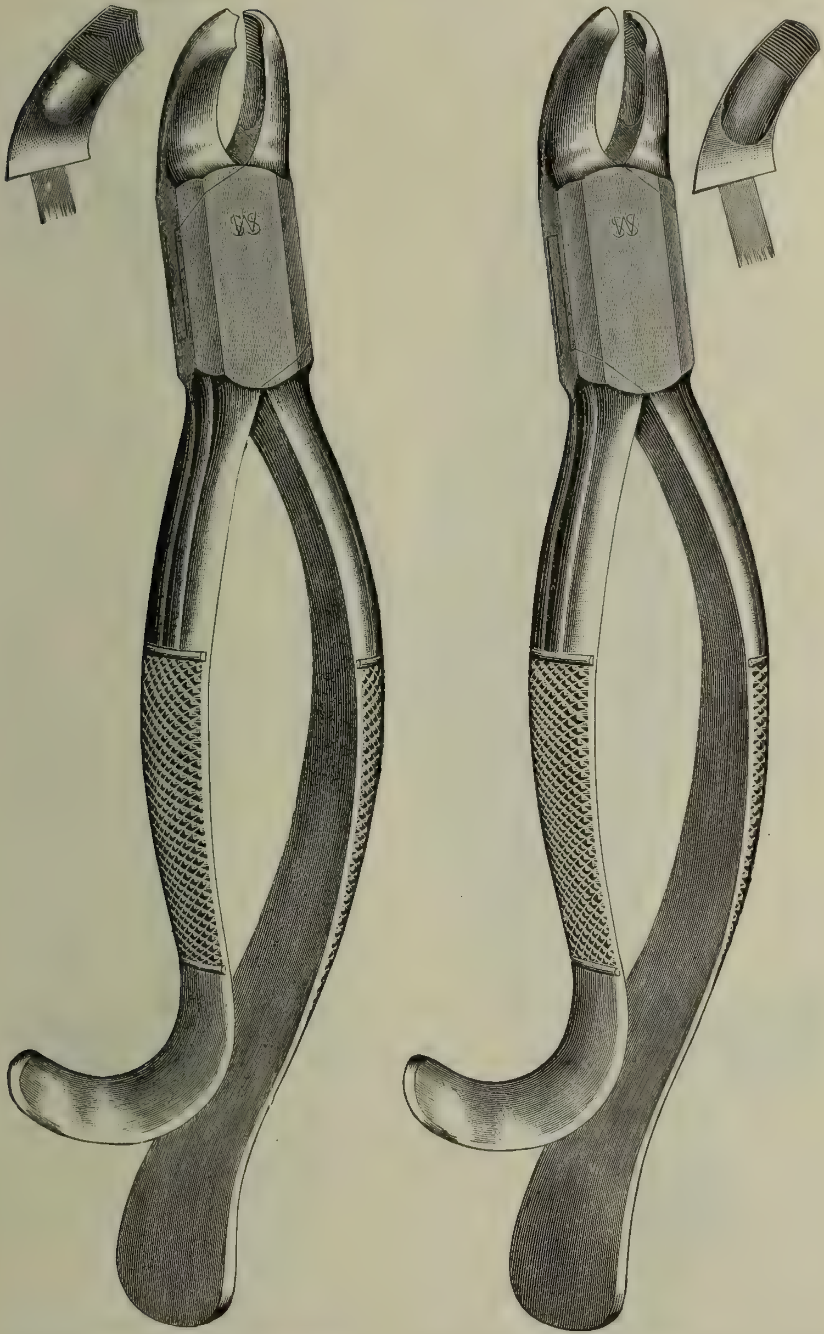
If a root is to be cut out from its alveolus, unless the patient be under an anæsthetic, it saves pain to divide the gum-tissue (with a sharp lancet or bistoury) to the bone on each side of the jaw directly over the axis of the root previous to using this instrument. The forceps blades should be held directly over this line on the bone to be cut, with the blades just far enough apart to prevent their impinging painfully upon the tissue; then with a quick motion the cutting edges should be brought together upon the root. The piece of the tooth-root that is thus cut out will generally come away within the grasp of the blades, but if it does not it can be picked out by an ordinary pair of root-forceps.

This operation is wonderfully less painful than the boring or trephining around the root with the beaks of a forceps, even if serrated purposely for that work. It has the additional advantages of expediency and almost instantaneous rapidity of execution, with the comparatively more thorough and quick healing by first intention, as no tissue is lost save that of the tooth, and comparatively none is crushed or drawn out of place.

The straight upper molar forceps (Fig. 288) are not always capable of reaching back for the superior second molar tooth where the opening to the mouth is small, and to accomplish this what are known as the Harris forceps have been designed. They are of necessity of right and left patterns to permit the use of the buccal beak between those roots. This may be mentioned as one of their principal advantages over the plain beaked bayonet forceps, but the curvature of the whole instrument is very well suited to the work they are designed for, and makes them exceedingly efficient. These forceps seize so far between the bifurca-

FIG. 290.

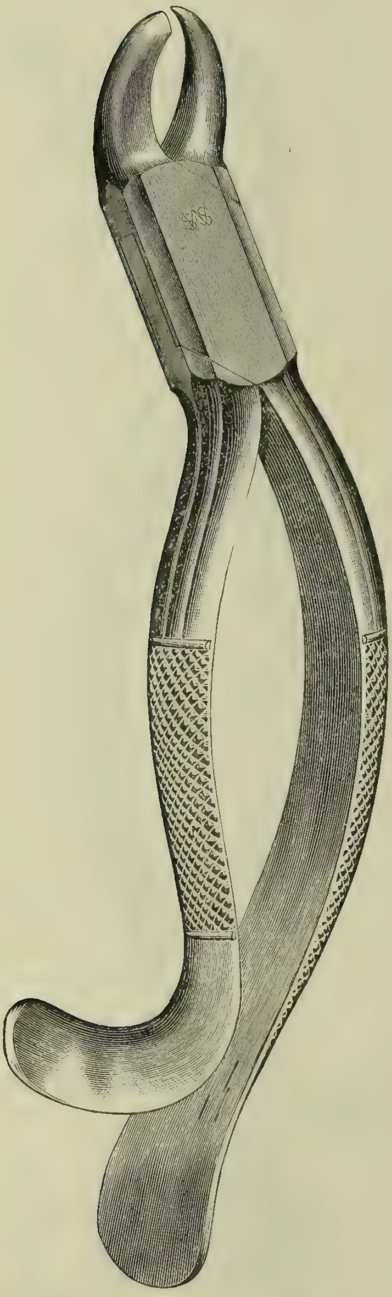
Buccal Beak. Lingual Beak.



Molar, Upper, Right side. (Designed by Dr. Chapin A. Harris.)

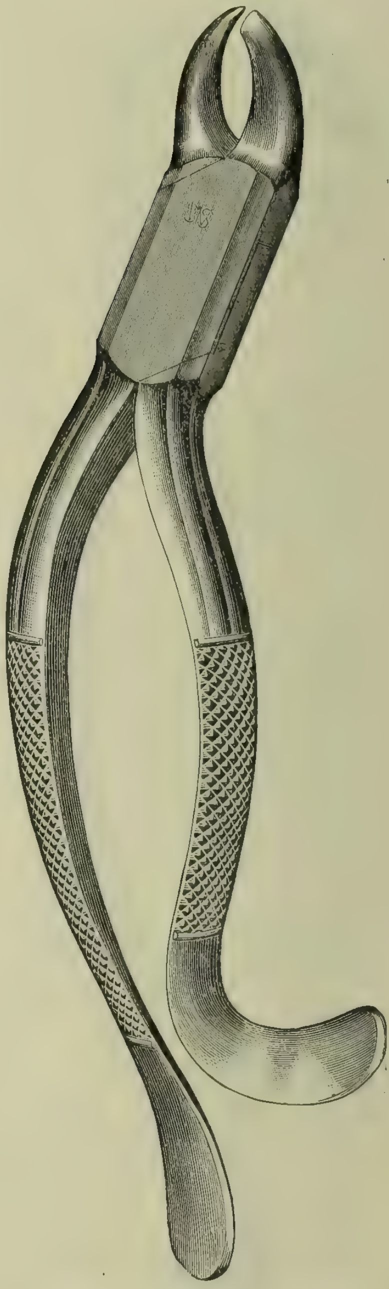
Molar, Upper, Left side. (Designed by Dr. Chapin A. Harris.)

Fig. 291.



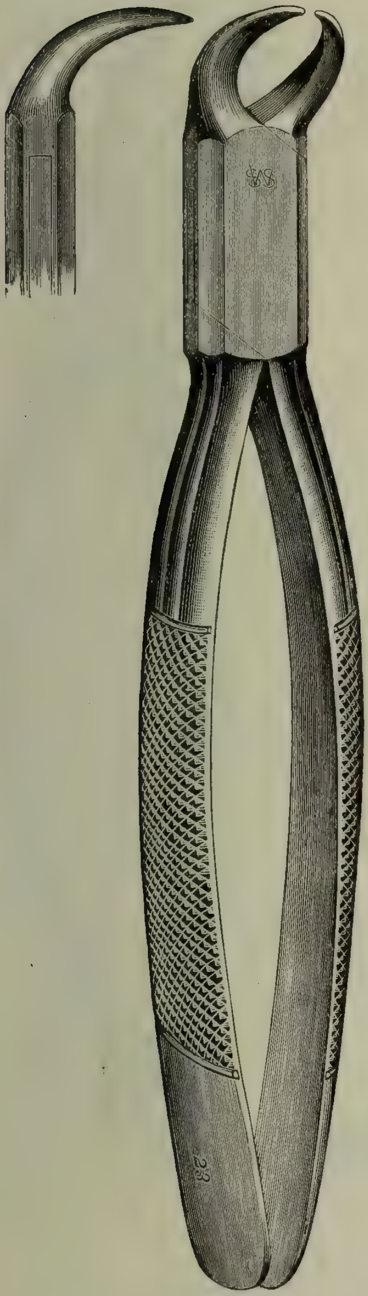
Dr. Maynard's Pattern, Molar, Upper, Left side.

Fig. 292.



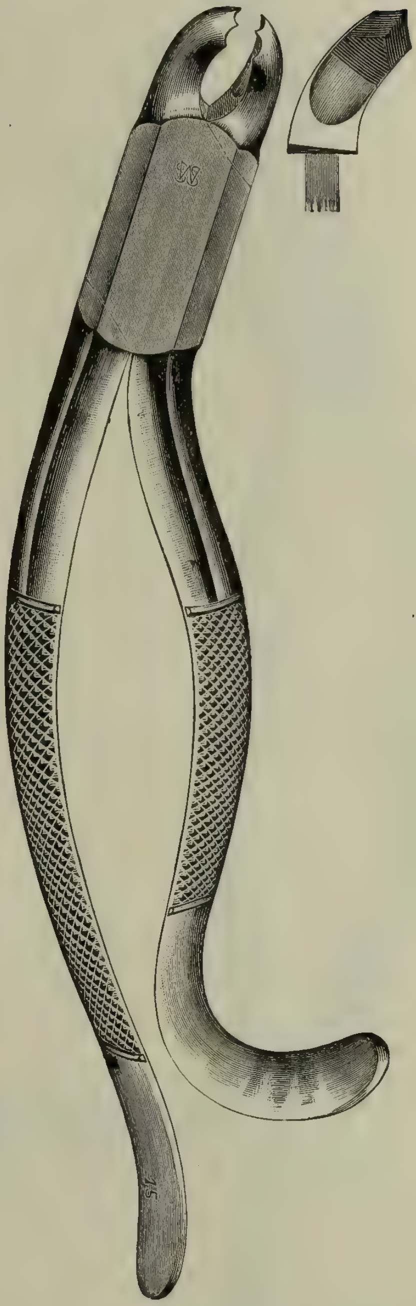
Dr. Maynard's Pattern, Molar, Upper, Right side.

Fig. 293.



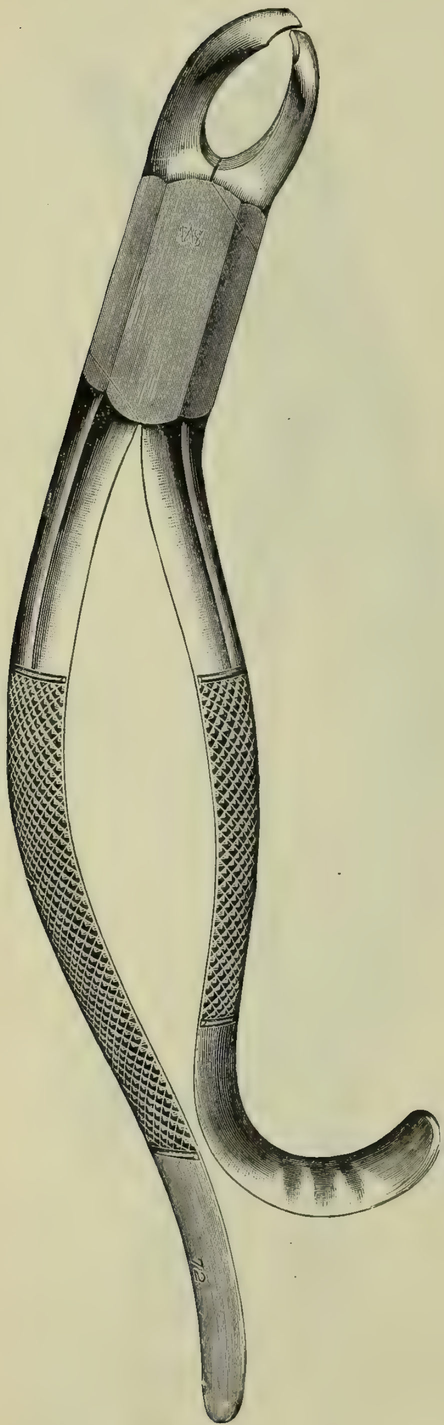
Dr. Maynard's Pattern, Molar, Lower, either side.

Fig. 294.



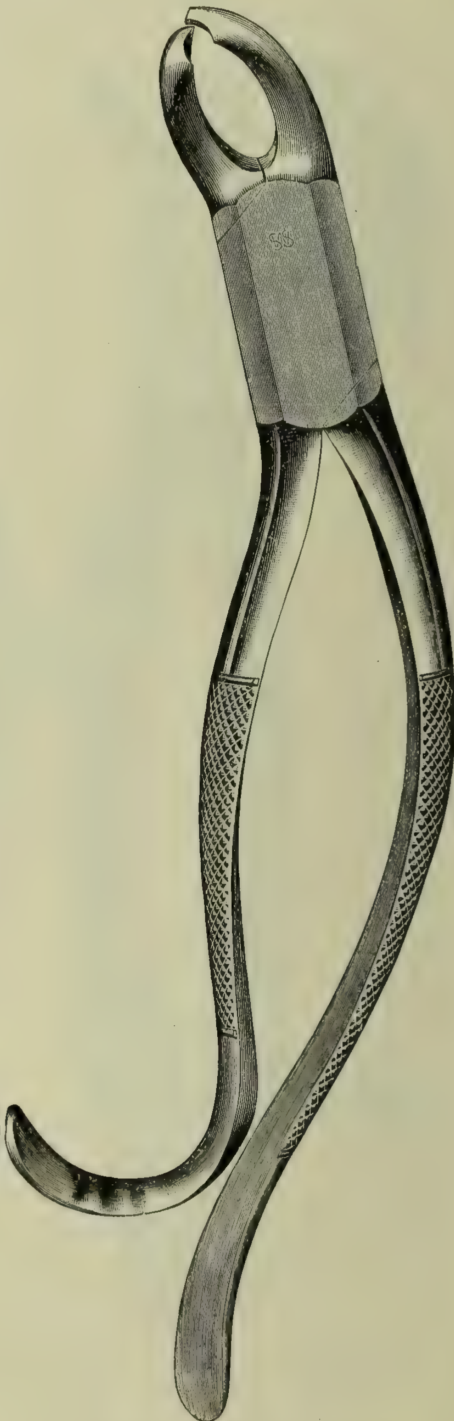
Molar, Lower, either side. (Designed by Dr. Chapin A. Harris.)

Fig. 295.



Molar, Lower, Right side. Smooth beaks.

Fig. 296.



Molar, Lower, Left side. Smooth beaks.

tion of the roots as to greatly lessen the danger of fracturing the crown.

Dr. Maynard, in view of the difficulty of extraction of the molar roots when the crowns are much weakened, has given to the profession a most valuable form of beak, which, from its resemblance to the horn of a cow, is frequently called the "cow-horn forceps," which designation has pretty much usurped the true name of the instrument. Figs. 291, 292, 293 show the set complete or for all molars. It need hardly be explained that the mere closing forces the beaks between the tooth-roots, and is often sufficient to lift them out on the principle of wedging, using the bone as a fulcrum. While at times this is a very painful operation, particularly if the tooth is firmly imbedded by hooking into unyielding bone, it has the advantage of dividing such roots by fracture when the crown is weak, and allowing them to be removed separately by the different forms of root-forceps.

The lower forceps are sometimes made with a curvature (Fig. 294) which is claimed to adapt them to a more direct pull upon the tooth. The writer has failed to find this an advantage, but out of deference to the preference of many operators, and under the conviction that all wrists are not alike, he has mentioned these forms so favored by many with whom he has differed. Their use will necessitate great care to prevent the fracturing of the upper teeth if the lower one should yield suddenly.

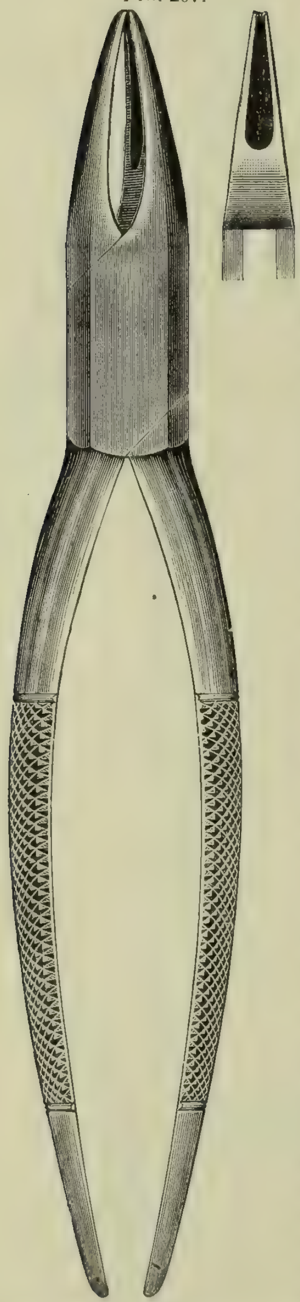
The multiform instruments for extraction shown in the dental dépôts and figured in their catalogues demonstrate how intricate the operation really is, and how much reason there is for classing the same as one of the most difficult in surgery. The father of oral surgery, a greatly respected and justly prominent man, Prof. Garretson, has asserted repeatedly before his classes that the extraction of a tooth has oftentimes proved more perplexing than the amputation of a limb, and he has many times performed both operations. The writer from long personal experience is convinced that with the selection of instruments named, with the addition of a pair of forceps having slender tapering spring-tempered steel beaks even slighter than the cut represents, the operator will be prepared with forceps for every case that will present to him. Fig. 297 represents a pair of root-forceps for the straight roots in the front of the jaws. The beaks of these instruments are much more slender and tapering than the ordinary ones sold at the dental dépôts, so as to admit of their being passed up between the root and its bony investment.

There will, however, here be added the description of the use of several most invaluable instruments for removing the roots of teeth.

Stump Extractors or Elevators and Screw.—The elevator is one of the most useful, and likewise least painful, instruments for root-extraction. It requires not only faith, but some dexterity in its use, and many have acquired such proficiency with the different forms that they have made quite wide reputations.

There are about four favorite forms (Fig. 298) which can be made supplementary to the forceps already described. They are used as follows: No. 2, with a blade like a heavy gum-lancet, is for insertion on one side between the tooth and bony wall of the alveolus. It can be

Fig. 297.



Root, Upper Front. Straight, long, slender beaks.

worked down by alternately pushing the elevator downward, and then prying the tooth upward, thus loosening and lifting the roots out. The greatest value of this elevator, however, is where the bone around the neck of the tooth is heavy and the roots are divergent or are hypertrophied, so as to require the enlargement of the opening in the bone to allow the roots to be brought out. In such cases the blade will stretch and wedge the alveolus wider open by the manipulation just described.

The elevator has been highly recommended for lower wisdom teeth, upon which it probably is most valuable, and yet it may be relied upon for both the molars and bicuspids. With the blade slightly narrower than shown in the cut—a change readily effected by grinding, and one that by no means detracts from the utility of the instrument—it can be of use upon other teeth.

Sometimes, after loosening the roots as above described, they can most readily be removed by the aid of the forceps, and occasionally it may happen that the root may be seized by entering the alveoli of the adjoining teeth or roots where recently extracted, and breaking through their walls to expose and grasp the root.

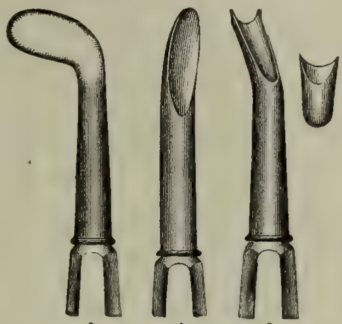
While the elevator just described is better adapted to the lower teeth, the next (No. 4) is more efficacious for the upper. Its insertion alongside of the root, and, by a partial twisting back and forth of the wrist, its working upward by boring and the loosening of the root, are steps so suggestive to even the ordinary observer as to need no further explanation.

No. 6 is used by making very much the same movement as that just described, and it is about equally well adapted to either jaw; by it the force can oftener be brought to bear more nearly in line with the axis of the tooth.

When adjusting these elevators the height of the operator's elbow should be slightly above his wrist for the lower, and below it for the upper teeth, and lowered or raised as may be necessary for removing the root. The instrument should be of a length to allow the index finger to cover and guard the point while the butt of the handle lies against that prominent part of the palm of the hand cov-

ering the distal portion of the carpal bones. The covering of the root of the tooth with the finger enables the operator to hold the root, and thus prevent its dropping into the throat of the patient. It likewise protects the mouth from injury in the event of the instrument slipping or by the root being very suddenly lifted out of its socket. In

Fig. 298.



Points of Stump Extractors or Elevators.

Screw for Extracting Incisor Roots.

all cases where these levers are used there must be as little pressure upon the adjacent tissues as possible, and this can be secured by careful bearing with the hand in such manner as to relieve the fulcrums.

The screw which is shown in Fig. 298 should be made to taper about as the diagram shows it, and with the longitudinal file cuts as in a screw-nut tap. The purchaser should insist upon these shapes, otherwise he may buy an instrument, as they are often made, with which he may split the tooth-root by forcing the too-suddenly tapering screw or by pushing up the débris before it without securing a firm hold for extraction.

Inserting the screw should be done by forward and backward quarter or half turns, as the screw-tap is used upon ivory, a little at a time; this may be continued until the hold within the tooth is very firm, or, if the root is much hollowed out, leaving it exceedingly thin, the head may be worked up with extreme caution until the noise of a slight split announces that the root will bear no more expansion.

The movements by which this instrument is inserted are generally sufficient to loosen the root, and its extraction is performed by very slowly increasing the force of the pull in the line of the axis of the root, which is also that of the instrument. Any deviation from this line will be dangerous to the root, the bone, and the instrument.

This process has the advantage of giving the least possible pain in seizing the tooth. Although sometimes it may be drawn out without bringing the root, it is easy to reinsert it and renew the attempt if there

be no inflammation about the pericementum. It should, however, be borne in mind that nearly all roots capable of this method of removal are quite likely to be worthy of retention and crowning; therefore the limitations of the use of this instrument are increasing with every additional improvement made by modern dentistry in crowning processes.

The use of the excavators for the removal of the tips of the delicately-pointed roots that sometimes are broken off and left in the sockets need hardly be explained, but it may be remembered that often little more than the atmospheric pressure holds them in position, and if the point of the instrument only enters at the side sufficiently to admit the air under the root-apex, force is scarcely necessary to bring it out. The movement of the instrument should be from side to side, with slight pressure to work it slowly up into the alveolus. Using the scoop brings this motion to a sort of rolling or zigzag that is not very painful, and that avoids the pressing of the point of the root upon the nerve-filaments at the fundus of the alveolus. The presence of these filaments also explains the cause of the very acute suffering produced by pressing up the forceps beaks in attempting to seize such fragments.

The deciduous teeth are generally subject to removal by these simple excavators, but at times they become wedged between the permanent teeth so firmly that to avoid injury to these adjoining teeth the precaution should be taken of filing the tooth apart, as is said to have been invariably practised by the famous Ambroise Paré preparatory to extracting. A curious case of retention of the superior deciduous canines in an adult, and later the loss of one leaving a large space between the cuspid and first bicuspid, has just been seen by the writer. This so aptly illustrates the damage resulting from leaving deciduous teeth to too late a period that it is mentioned, although it is the only case remembered to have been seen where the retention of this tooth did not produce irregularity of the curve of the arch if all the permanent teeth erupted.

Those roots that are small and roll against each other when separated from the crowns, as the bicuspid and wisdom teeth oftenest do, are frequently most readily removed by the excavator when the forceps utterly fail to grasp them firmly. In these operations much depends upon keeping out the blood, which, if allowed to flow freely over the parts, obscures the view, and in addition makes the parts slippery. To staunch this it is often well to throw, with considerable force, from the nozzle of a syringe a stream of quite hot or very cold water, wiping out the cavity with spunk (agaric); sometimes the use of medicinal styptics to be mentioned in the local treatment of hemorrhage is necessary. It is fortunate that in most cases such tips of the roots as above described give but little inconvenience if not jammed and driven into the bone by attempts to seize them with the ordinary root-forceps; in which event they undoubtedly would act as very effective irritants.

If left entirely alone, however, they will generally slowly work toward the surface, and can then often be picked out with the fingernail. Efforts to extract a tooth which at first prove futile may generate sufficient inflammation to thicken the periosteum and lift the tooth

in its socket enough after a day or two to make the operation very easy to accomplish.

Gum bands cut from rubber tubing may be pushed up around the tooth by wedges and other devices, so as to cause the same condition. These should oftener be used to help in the preparation of the tooth for extraction. If time is taken for the work, and the readjustment of the wedges or bands persevered in, fresh ones being added to keep pressing the first upward toward the apex, the tooth may be so loosened as to almost fall out without any interference.

Accidents following Tooth-Extraction.

The observation of the precautions already advised will prevent many of the accidents attending tooth-extraction; but the dentist must nevertheless be prepared to give his advice to those who suffer such casualties or in cases of consultation. It is his duty to keep fully informed upon the best means of meeting and averting the dangers of the mishaps of others.

Syncope, or fainting, is one of the most common, and at the same time least avoidable, complications. Fortunately, many of the most ordinary cases of this trouble need but little treatment other than to cause the blood to flow to the head. This may be most readily accomplished by placing the patient upon the back, and, if necessary, elevating the feet so that by gravitation a sufficient supply will pass to the brain. Our modern dental chairs render this very easy to accomplish.

Stimulation by wine, whiskey, or brandy may be desirable to increase the heart's action, but the use of these remedies should never be attempted except under the most conscientious precautions. The weak-minded and foolish who abuse the blessings of the wine-cup are ever ready to excuse their gluttony and drunkenness, which may soon become criminal, by accusing others with having tempted them, and often they succeed in casting blame upon those who are innocent, so as to disguise their own lack of self-restraint and self-respect, for which they are best aware how plainly they are responsible. When alcohol is used as a remedy, it must be subject to such restrictions as double-edged weapons require. Name carefully the dose and the limit, and entrust it only to those who will faithfully and implicitly obey the directions, or, what is better, trust no one, but administer it in person.

Ammonia, as in the form of carbonate, the ordinary smelling-salts, or the fumes from ammonia-water, may be inhaled, but it must be remembered that the strong fumes will produce excoriation, and they should only be applied for a second at a time, or the aromatic spirit of ammonia may be administered in doses of half a teaspoonful in half a wine-glassful of water, to be repeated until the patient recovers. This remedy, however, is not so lasting as the alcoholic stimulus. The circulation may likewise be accelerated by rubbing or slapping the hands, or by the momentary application of a cloth wet with cold water to the face or chest. The patient should not be allowed to assume the upright position too suddenly, nor can one safely resume heavy labor immediately

after recovery. Fainting is not infrequently brought about by the sight of blood, and it therefore may become the duty of the dentist sometimes to administer to the friend or attendant of the patient. The bloodless, almost waxy or ashen hue of the lips and face, the sighing or suppressed respiration of this condition, make it readily distinguishable from that unconsciousness which is the result of determination of the blood to the head. This latter state is accompanied by turgidity of the vessels, causing the eyes to be bloodshot and the face purple or livid.

Treatment should be pursued promptly to relieve the congestion by keeping the head upright and cool, and inviting the blood to other parts by means of warm foot-baths and dry cups to the nape of the neck. With the plethoric venesection may be necessary.

Hemorrhage.—Probably the most frequent cause of this alarming difficulty is the fracture or injury of the portion of the bony wall of the tooth-socket, in which the enveloped blood-vessels are likewise the sufferers. The remedy under these circumstances is first to remove the loose pieces if not too large and the strips of gum if torn, remembering that in ragged wounds bleeding is more quickly arrested than, although not always so promptly healed as clean-cut surfaces, particularly where the latter can be held closely together. By a pledget of lint or cotton keep up a gentle pressure. The latter may be done best by replacing the tooth-root, or in some cases by a temporary plate of metal or gutta-percha. If possible, exact coaptation of the parts should be secured. Styptics applied locally were in former times more relied upon than of late; they likewise have their value for arresting bleeding, although far below that of pressure, since by their use, if of sufficient strength to accomplish the purpose, it commonly happens that the healing of the wound is delayed or sloughing of the parts is produced. The combination of these two remedies is so rarely unsuccessful in practice now that death from hemorrhage after tooth-extraction seems to have become more rare than after slight wounds or accidental scratches. The barber-surgeon has been followed into oblivion by the barber-dentist and the blacksmith tooth-puller; in their stead are those whose higher education and better judgment enable them to recognize and treat the diathesis, to palliate the suffering, and to delay the operation until the patient's general health is improved. There now is rarely one half the violence used which the best instruments of a former generation inflicted. The treatment, the filling, and the preservation of the teeth are continued until many of them need no further means than the patient's fingers for their removal, when that final resort is necessary. The improved instruments and methods have wrought their share in the revolution of this branch of the healing art.

Tannic and gallic acid are the styptics which have the most to recommend them and the fewest objectionable features. Tannic acid is the more powerful in its action; either it or the gallic acid may be used in powder or crystals or solution. The former is generally the most efficacious, and should be worked through the dry cotton wool or dusted upon the pledget slightly moistened with water, alcohol, glycerin, or oil of cloves; the dampness serves to keep it on the cloth.

Tannin is so general in its distribution in the vegetable world as to

make it very accessible. The ordinary sole leather is a ready means of obtaining it, and by applying it dry and rasped or shredded the moisture of the wound forms it into a pulp that may be packed against the bleeding surface by the addition of sufficient of the material until the wound is plugged up and the flow stanched. Agaric and amadou are preparations owing their virtue to the same principle, and are convenient forms for applying the same to the bleeding surfaces.

Matico is another vegetable and very useful hæmostatic, combining with this power the virtues of an alterative stimulant to the mucous membranes. The leaves may be applied in a ball or roll, fresh if they can be so obtained, or dried or powdered, as they are to be had in most pharmacists' shops.

Alum in saturated solution in water makes an excellent styptic for the mouth, being easily obtained, simple to prepare, and most effective; it has but one objectionable feature that makes it second in value to tannin—namely, that if kept long in contact with the teeth it may act injuriously upon their enamel. The most efficient method of using it is to throw it forcibly from the nozzle of an ordinary dental syringe upon the part from which the blood flows. This washes away the imperfect coagula and exposes the points at which oozing takes place, enabling the absorbent cotton wool or lint with the powdered alum or saturated solution to be packed directly upon the opened vessels.

Cold applications are of great value, and the watery solutions just recommended may be made cold by ice, or the latter substance may be used directly in pointed sticks or crushed masses, or steel burnishers may be chilled and then put upon the parts. From an appropriate syringe or apparatus cold water or air may be thrown upon the wound.

Heat may be of great service applied as above by air, water, or metallic substances; the latter being more easily managed and less likely to produce painful impressions upon other parts of the mouth. The heat of the cautery-iron need not be so great as to destroy and make crisp the tissues, the object being merely to cause coagulation of the albumen.

Nitrate of silver closely resembles the preceding remedy, and has largely, but perhaps less justly, displaced the same. The convenience of its transportation and its immediate readiness for use are of course strong arguments in its favor.

A coal of fire, as recommended by the writer, may be made of the end of a piece of hickory pivot-wood or of an ordinary wooden match-stick, which is nearly always at hand, most ready, convenient, and less terrifying to a patient than either of the above means of applying the cautery. The knack of touching the part by cautiously and deliberately approaching it and suddenly drawing away the fire can be acquired, so as to give but little and only momentary pain.

Perchloride and Persulphate of Iron.—These salts may be used in solution or in powder, as has been described, mixed through the cotton or dusted over the dampened surface. The latter, which was introduced as Monsel's salt, being used by him as a hæmostatic, became at one time a very great favorite in dental surgery, but so many cases of

secondary hemorrhage resulted from the destruction of the tissues and their subsequent sloughing away that its use in the mouth is now almost discarded by the experienced.

Spider's Web.—This has become almost exclusively a domestic remedy, and in the case of any ordinary abrasion during the pressing duties of the general house-cleaning it seems to answer a purpose. The house-spider is said to be the only one whose web is efficient. The writer's experience with it has been enough to pronounce it fairly efficacious, but quite painful for superficial wounds.

Oil of turpentine has the same objectionable feature as the above, producing sharp smarting pain, but as a styptic it acts moderately well upon the wounds of the derm.

The failure of all these means of arresting the flow of blood demands that rather than that the danger of death from exhaustion should be risked the surgeon should attempt the operation of ligation of the external or the common carotid artery. So serious and dangerous an operation, fraught with the risk to the nourishment of the brain by the change of the route of the supply, will require that every other alternative has been tried in the most skilful manner before resorting to this.

The tincture of *Erigeron Canadense* and the extract of *Hamamelis* (witch hazel) have been lauded as certain specifics for the stoppage of bleeding. Their use, however, has in the writer's experience scarcely sufficed to allay alarm. Most cases of hemorrhage following tooth-extraction will recover by reason of the exhaustion of the supply and force of the flow. During the time that this reduction of the heart's energy is coming to pass the patient and the interested spectators are impatient, and naturally desire that something should be done. A drop dose of any harmless astringent, as tincture of krameria, repeated every five minutes, serves to give employment and sustain the hope of the laity and distract their attention.

Fracture of the Tooth.—This may be more or less serious according as it leaves the remainder in a position to be readily grasped and removed. In some cases of interlocked or crooked and hooked roots it is an advantage, as it admits of their being removed separately, and is therefore intentionally practised and recommended. In other cases it is exceedingly unfortunate, as it compels the operator to cause more serious injury upon the surrounding tissues, so as to enable him to grasp the portion that is *in situ.* It has already been explained that the injury inflicted by attempts at extraction may be such as to far outweigh any benefit to be expected from the removal of the roots.

Fracture of the bone may, with very rare exceptions, be treated by bringing the parts together and leaving them to the enveloping tissues to be repaired. At times, however, it may be necessary to use ligatures or plates to sustain the fractured parts in apposition. To avoid this accident it may be necessary to file or saw apart the crowns or roots of those teeth that are found to be so associated; generally, however, the accidental fracture takes place both unexpectedly and suddenly. Whenever the movement of one of the teeth is found to cause a similar disturbance of either of the adjoining ones (Fig. 302), the safest plan would

seem to be to cut between them by means of drills or saws or files, so as to sever the connection, before proceeding to remove the tooth.

Where small portions of bone are removed adherent to the tooth (see Figs. 299 and 300), there is generally little damage except in the case of the tuberosity of the superior maxilla coming away with the wisdom tooth, which has been considered under the head of Hemorrhage.

Fig. 299.

Fig. 300.

Fig. 301.

Fig. 302.

Fig. 299. Upper First Molar Tooth, with a portion of the external alveolar-plate attached to it. From the form that the portion of bone presents, and its absence at the extremity of the fangs, it would have been almost impossible to remove the tooth without removing it as well.

Fig. 300. Upper Third Molar, with the tuberosity of the superior maxilla attached to it. In this case also the form of the bone rendered its removal with the tooth a matter of necessity.

Fig. 301. A Small Cyst in connection with a Bicuspid Root. The cyst had lost its vitality, and had given rise to an abscess in its immediate neighborhood; otherwise the cyst had no connection with the abscess.

Fig. 302. Three Specimens of Gemination. That on the right, from a specimen in Prof. Coleman's possession, is an upper second and third molar, in which the union is by cementum only (probably); that in the centre is an upper lateral incisor and cuspidatus of the left side; and that on the left hand is an upper lateral and cuspidatus of the right side, as seen from behind, copied from preparations in the museum of the Odontological Society of Great Britain. (After Coleman.)

This may be removed from the tooth by putting one beak of the forceps upon the tooth and the other upon the bone, and closing the handles. It is well not to show these to the patient, as it only occasions unnecessary alarm.

The union of teeth as shown in Fig. 302 is occasionally seen to be above the gum, but most frequently it is of the cementum below the exposed portions.

Sometimes where an erupting wisdom tooth cannot be treated or removed, it impinges upon the second molar (Fig. 303) so as to require the removal of that or the first molar tooth to relieve the pain caused by the crowding of the former. At times a lower wisdom tooth wedges in between the second molar and the ramus of the jaw, so as to make its removal very dangerous and necessitate the extraction first of the tooth against which it is crowding.

Fig. 303.

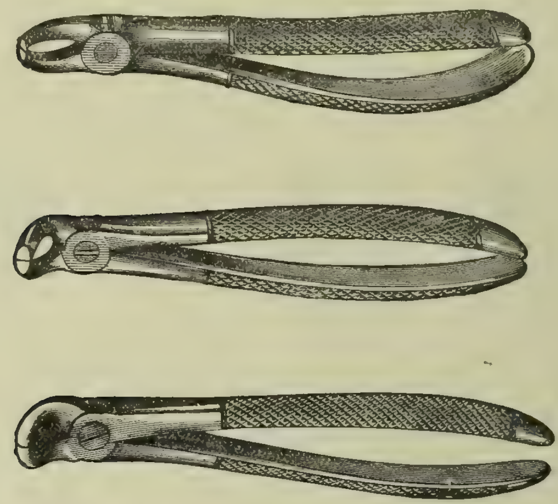
Unerupted Wisdom Tooth, which by pressure has caused absorption of the proximal surface of a second molar. (After Coleman.)

Where there are projecting points of the septa and walls of the bony alveoli, they should be snipped off by some of the cutting forceps (Figs. 304 and 305). This procedure hastens the recovery and the preparatory healing of the mouth for the wearing of artificial dentures. The irritation caused by such projections

may not only delay the healing, but actually cause ulceration of the tongue or cheek in contact with them.

The extraction of the wrong tooth, an inexcusable blunder that cannot often be classed as an accident, may be treated by replantation.

FIG. 304.



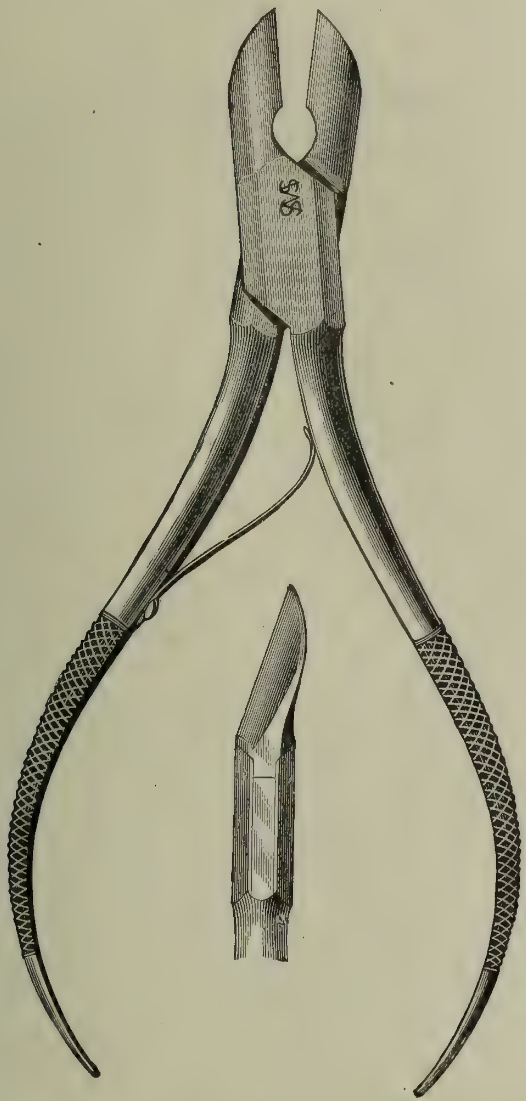
Three Forms of Forceps suitable for cutting away projecting forms of alveolar process, etc. (After Coleman.)

Luxation of the jaw, a very rare complication, may be possible in cases where there is an unnatural predisposition to this accident. The reduction depends upon the lowering of that portion of the jaw in which the molar teeth are situated and drawing upward the anterior part. This is accomplished by the operator's hands seizing the jaw with the fingers and placing between the molars the thumbs, wrapped to protect them from being bitten by the sudden occlusion of the teeth when the condyle slips back into its natural position. A flattened stick may be used between the teeth as a lever for the same purpose.

The danger of the wisdom or other tooth slipping down the throat or being drawn into the air-passages has been spoken of, and the operator cautioned. If the accident should threaten, a resolute operator may quickly catch the tooth with his finger or the forceps. He must not lose his head or neglect to watch every step in the operation and keep upon the *qui vive* to avoid the accident.

The writer some years ago had a curious experience in the extraction of two molar teeth that seemed to be attached to the bone, so that their removal brought a rough and spiculated covering of the entire roots that had the appearance and feeling to the touch as if it might be the inner layer of the alveolar walls. The specimens were supposed to have been laid aside for microscopical examination, but have been searched for as

Fig. 305.



Wedge-cutter.

yet in vain. There resulted no untoward trouble from the operation, and the same condition had been the experience of a fellow-practitioner who sent the patient to the writer.

SUPPLEMENTARY CONSIDERATIONS.

There yet remain some few matters for consideration that now will be mentioned.

Reflex Pain.—The nervous system has been compared to a hotel annunciator, and, like it, is sometimes liable to a peculiar train or class of phenomena by which, as already intimated, the patient who is suffering from pain or distress in one organ refers it to another. This condition has its counterpart in the entangling or disarrangement of the wires of the system of bells, which generally occurs in proportion to the imperfection of their condition and the number associated. In the nervous system of man we find the afferent and efferent nerves crossing or associated at the various ganglia; which seems to be the most natural explanation of the perversion or disturbance of the perception of a sensation passing to the brain. By constant use nerves become capable of more perfectly and promptly conveying the impressions from without to within, and *vice versâ.* Thus they may be said to be improved or educated by systematic use. From this it may be understood how it occurs that teeth which have rarely given to their possessor any notice of their existence are, when the seat of irritation, proportionately likely to make a false impression, and conversely the patient whose dental nervous apparatus has been cultivated by repeated impressions is more trustworthy as to which tooth is the source of pain.

Walking, playing upon musical instruments, and various habitual exercises are familiar examples of the manner in which actions at first dependent upon the will may become more and more automatic or reflex, until they can be carried on without any voluntary act on the part of the walker or performer except at the beginning or when met by some obstruction in the path or more difficult passage in the music.

These considerations are of the greatest value when attempting to discover the tooth that is the active or passive cause of the sensation complained of, since that influence, begotten of habit, must be allowed for. The reflex pain may appear to be from one of the adjoining teeth or from the corresponding tooth of the opposing jaw, or of the same jaw, but upon the opposite side.

Teeth should not be Extracted while Aching.—Many of the most troublesome cases of neuralgia are those that follow the extraction of an aching tooth. Whether this is due to the fact that when the peculiar train of vibrations has once been induced such vibrations are more readily revived, or whether due to a permanence of the impression on the nerve when some injury has been inflicted during the performance of its function, or to the compression of the terminal points of the filaments by the cicatrix that embraces them, it still holds true that an operation should be forbidden when the nerve is transmitting painful sensations, and therefore is in an abnormal condition.

Should a tooth be surrounded by congested tissues, as during inflammatory activity or inactivity, there is the danger of greatly augmenting the same by the violence inflicted upon those adjoining tissues by the breaking up of the connection between them and the tooth. It acts much like cutting, tearing, or squeezing an ordinary boil before it has completely ripened or pointed; and unless the tooth be very loose or is capable of removal with little or no crushing or violence, or the limitation of the pus-formation has been reached, the difficulty and pain are proportionately increased.

After Extraction the Alveolar Walls are generally found more or less Pressed apart, especially in those cases where the tooth was firmly held in its position; this is almost invariably the case if the roots have been exostosed or divergent. After such operations gentle pressure or squeezing of the alveolar process between the thumb and finger of the operator will do much to relieve the pain by replacing the parts in their original positions; attention to this precaution will also diminish the size of the cicatrix which will fill the vacancy made by the removal of the tooth-roots. The bleeding may often be arrested in this manner, and we may avoid the insertion of a tampon or plug, which latter is often a serious cause of pain and a hinderance to repair and healing by holding open the alveolus. By this means may be averted secondary hemorrhage following the removal of the tampon, sloughing, and the greater dangers of putrefaction of the blood-clot and animal matters in the tent or plug, together with the deleterious poisonous influence exerted by them upon the adjoining living tissues.

In ordinary cases no more safe and thorough purification of the wound can be had than by the outward flowing of the blood, floating away the foreign matters, and the perfect filling up of the space by the coagulum, preventing the ingress of external irritants.

When the Primary Hemorrhage is very Slight, it is generally a Cause for Anxiety.—The shock which is the result of the violence of extraction may be the cause of an almost total arrest of the blood-flow, and when the parts react, they often do so with increased and abnormal force. The re-establishment of the circulation may bring about secondary trouble. Therefore it is generally best to keep such patients under observation for several days until all danger has passed.

Sometimes in Extracting a Deciduous Molar before it has been Loosened sufficiently by Natural Processes, the Crown of the Underlying Permanent Bicuspid may be Brought away with it.—The avoidance of this accident is best effected by waiting for the complete or almost complete detachment of the milk tooth.

The Wedging of an Erupting Bicuspid between its Fellow and the adjoining First Molar, or more rarely the Canine, causes it to be more endangered by the accumulation of decomposing food over it, and caries from this cause may render its extraction advisable. Under such circumstances it is rarely practicable to cut or file it enough to admit of its removal, but this may be accomplished by first pressing it outward or inward from the line of the arch of the teeth.

When Roots are very Frail and Liable to be Crushed under the Grasp of the Instrument, they often can be made better capable of resistance

by plugging them temporarily with soft wood, gutta-percha, amalgam, or some such material as will support and sustain them against the pressure.

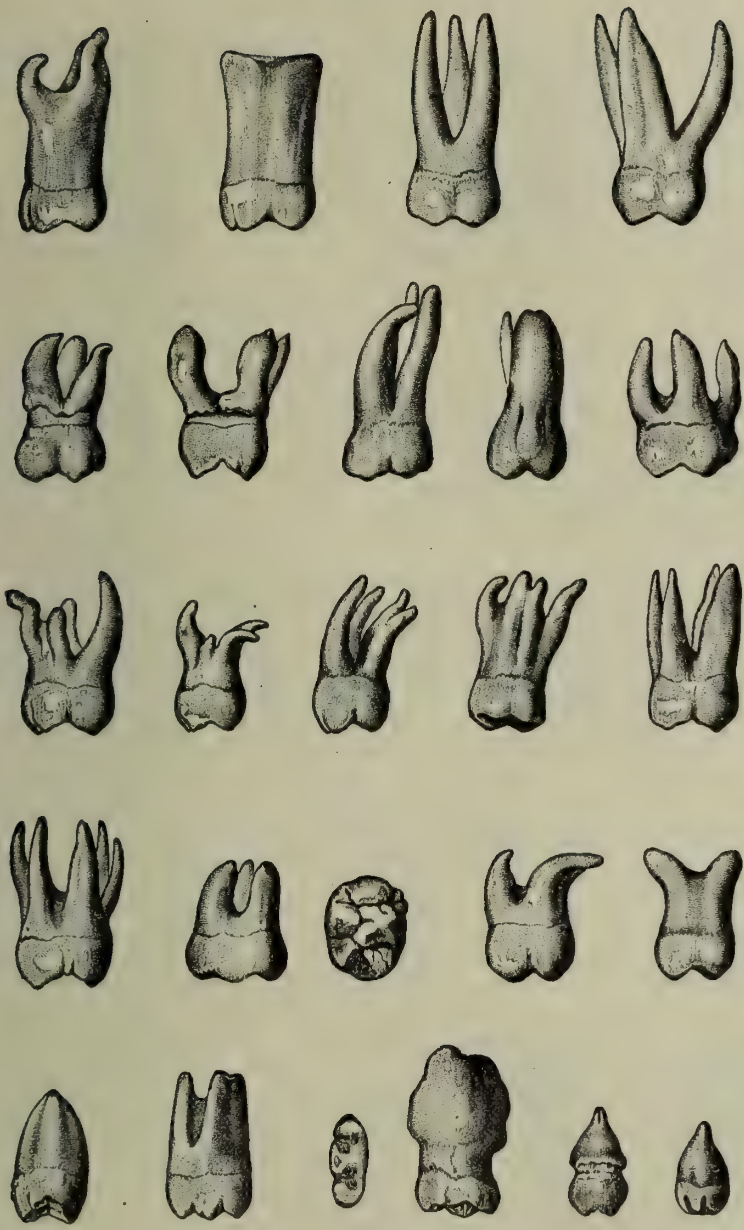
The Insane, the Idiotic, and Children sometimes Refuse to Open their Mouths, or, actuated by anger and revenge, they may bite the operator's fingers viciously. In such cases the dentist can quickly compel them to open by pressing up through the floor of the mouth from the outside with the end of a finger of his left hand upon the point of entrance of the inferior dental nerve at the inferior dental foramen under the angle of the jaw.

Where the Mouth cannot be Opened by Reason of Partial Ankylosis or other Cause, it may be gently pried open with a flat stick of tough wood or by means of the various surgical appliances for this purpose, such as the lever, the screw-gag, or the wedge of Scultetus.

Where Sufficient Space cannot be Gained to Admit of the Use of the Forceps, the friends of the key instrument claim it to be of service.

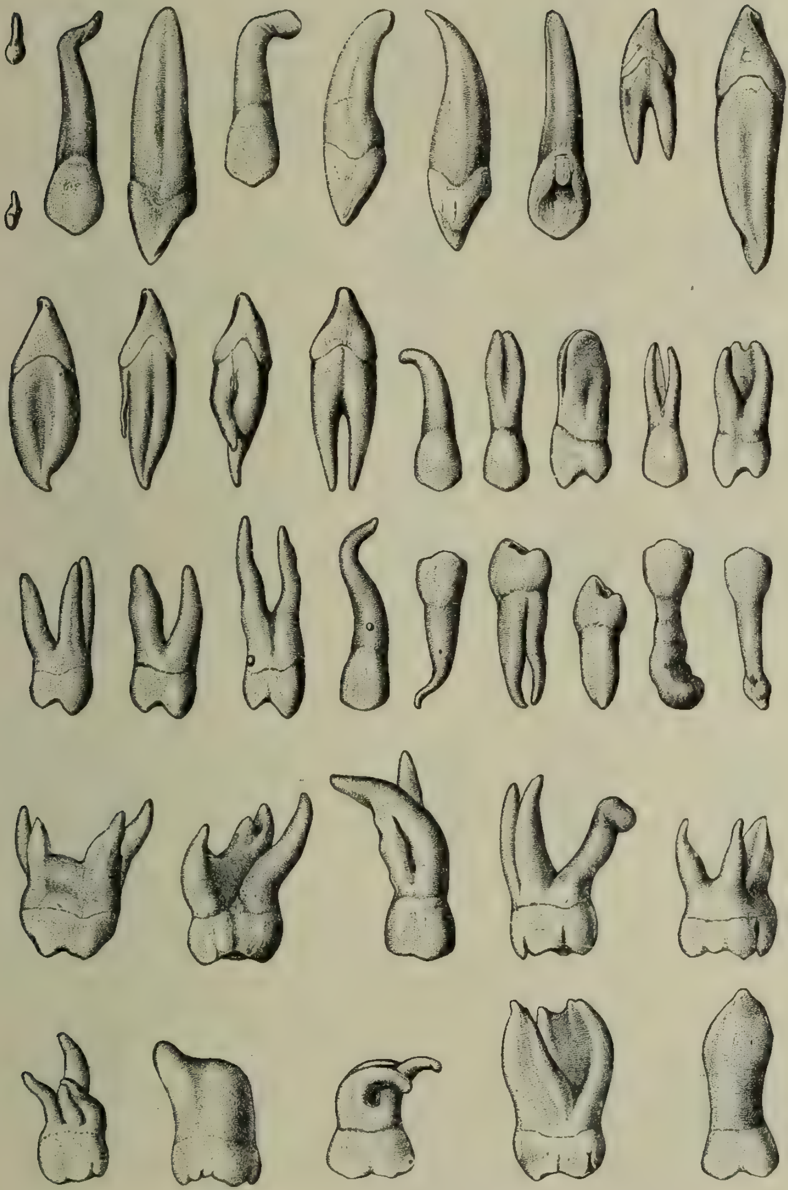
The Grasp of the Forceps is often made more perfect, while at the same time the separation of the beaks is more readily effected, by the insertion of the thumb or first or third finger between the handles, so as to press them apart enough to embrace the tooth.

PLATE I.



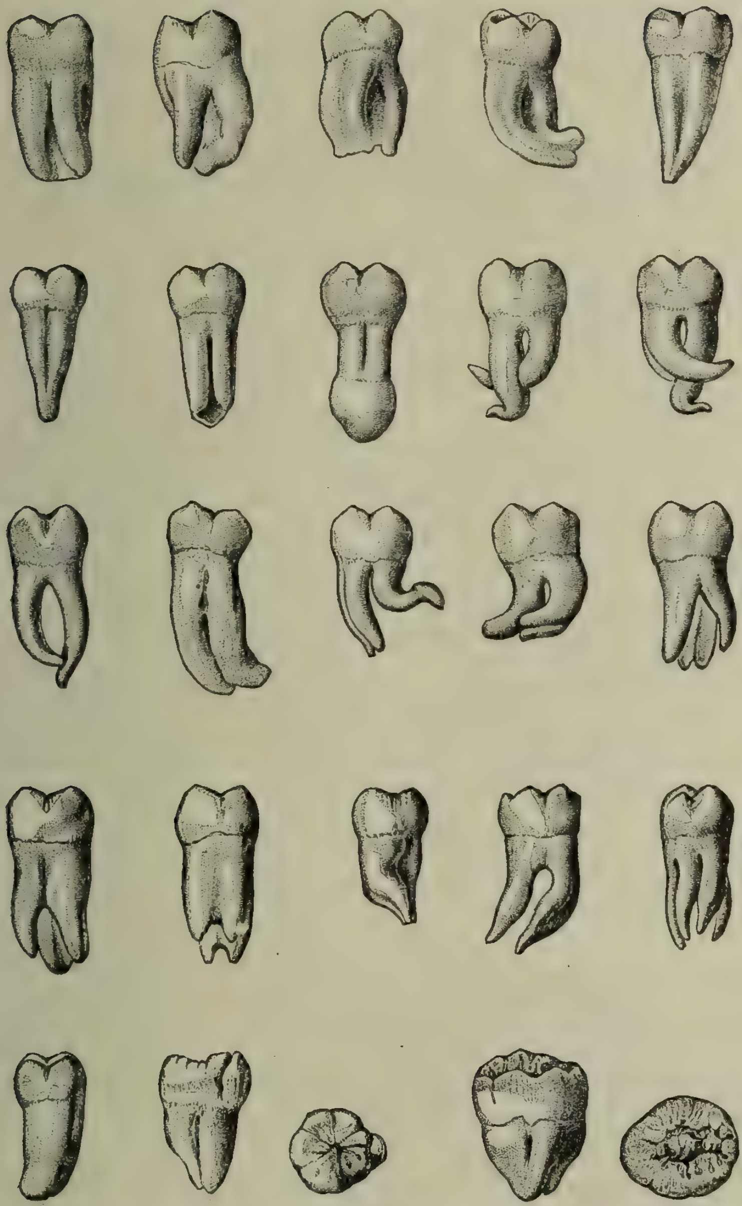
Specimens of Abnormally-shaped Teeth, including Fused, Exostosed, and Multirooted.

PLATE II.



Specimens of Abnormally-shaped Teeth, showing Exostosed, Bifurcated, and Twisted Roots.

PLATE III.



Specimens of Abnormally-shaped Teeth, showing Fused, Exostosed, and Hooked Roots.

PART II.

PROSTHETIC DENTISTRY.

TAKING IMPRESSIONS OF THE MOUTH; PLASTER MODELS; ANTAGONIZING AND CONTOUR MODELS.

THE GEOMETRICAL AND MECHANICAL LAWS OF THE ARTICULATION OF THE HUMAN TEETH.—THE ANATOMICAL ARTICULATOR.

METALLIC DIES AND COUNTER-DIES.

ARTIFICIAL DENTURES ON BASES OF GOLD AND SILVER.

ARTIFICIAL DENTURES OF ENAMELLED PLATINUM (CONTINUOUS-GUM WORK).

ARTIFICIAL DENTURES ON BASES OF FUSIBLE ALLOYS.

ARTIFICIAL DENTURES ON THE RUBBER BASE.

CELLULOID AND ZYLONITE.

ARTIFICIAL CROWNS (PIVOT TEETH).

A SYSTEM OF AN ALL-PORCELAIN CROWN SUBSTITUTION.

CROWN- AND BRIDGE-WORK.

METALLIC FACINGS FOR CARIOUS CROWNS.

MOULDING AND CARVING PORCELAIN TEETH.

THE HYGIENIC RELATIONS OF ARTIFICIAL DENTURES.

DENTAL AND FACIAL TYPES.

OBTURATORS AND ARTIFICIAL VELA.

TAKING IMPRESSIONS OF THE MOUTH; PLASTER MODELS; ANTAGONIZING AND CONTOUR MODELS.

By A. G. BENNETT, D.D.S.

I. Impressions.

A PERFECT impression and a correct articulation constitute the basis of prosthetic dentistry. On no other basis can a denture be constructed which embodies the highest ideas of utility and beauty. Given an imperfect impression, the most accurate workmanship avails little or nothing and the most artistic mechanism is all the more disappointing to patient and operator.

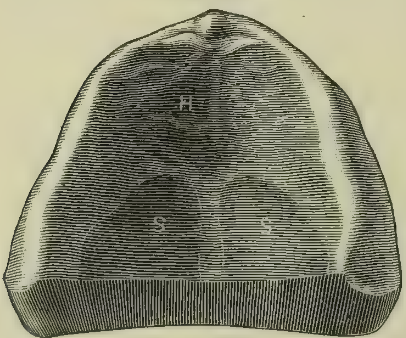
Condition of the Mouth.—When an artificial denture becomes a necessity, it should be so constructed, and the mouth should be in such a condition, as to secure the highest degree of comfort, usefulness, and durability. The first requirement is that all tissues which have any relation to the base-plate must be healthy. This demands the removal of all irritants—tartar, roots of teeth, and all diseased teeth that will not yield to treatment—and requires the use of such remedies as will restore the parts to their normal status; for even with this condition and that of absolute cleanliness it is not always possible to overcome the pathological tendency induced in the mucous membrane by the pressure of a closely-fitting plate or the irritation inseparable from a loose one.

Preparation of the Mouth.—When artificial teeth are to be inserted on a plate in a case in which some of the natural teeth still remain, and are in a firm and healthy condition or comparatively so, it is necessary to have some definite rules as to the teeth that should be retained in the mouth. The two most comprehensive rules that can be given for the extraction or retention of the teeth under these circumstances are based on their liability to decay and the inherent obstacles to retaining artificial substitutes. As regards full dentures, upper ones are more securely and comfortably retained than lower ones; and as regards partial dentures, those replacing upper anterior and lower posterior teeth, especially the latter, are the most satisfactory. Other things being equal, therefore, the preservation of the lower teeth is more desirable than that of the upper ones; and of all, the retention of the lower front teeth is the most important. In regard to the number of healthy teeth that should be allowed to remain in the upper jaw, it may be stated that, as a gen-

eral rule, one, two, or three teeth standing in different places or on one side of the mouth should be extracted; and that four molars, and sometimes the central incisors and the cuspids, should not be removed. The front teeth of the lower jaw, unless too much diseased, elongated, or very irregular, even though only the incisors remain, should not be extracted. But two or three lower molars, when elongated or leaning, should be taken out. In cases where the lower front teeth are worth saving, yet are somewhat displaced or uneven from wear, thus presenting obstacles to a correct articulation, they should be filed or ground off and polished before taking the "bite." And it may be observed in general that when a plate is to be worn it is good practice to simplify very difficult cases in either jaw by judicious extraction. This applies particularly to loose or displaced teeth standing alone. When teeth are extracted an interval of from one to three weeks for temporary sets, and from six to fifteen months for permanent sets, should be allowed for healing and absorption before taking the impression. It is desirable in all full and all partial cases of more than four teeth, particularly in the upper jaw, that temporary sets should be worn—if for no other reason than to prevent change in the muscles and other tissues that give to the face its characteristic expression, which when once lost it is often difficult, and sometimes impossible, to restore.

Examination.—Assuming that the mouth is in a proper condition for an artificial denture, the next step is to observe the size, shape, and height of the arch, the hardness and softness of the palate, and the length or height and form of the alveolar ridge. In partial cases it is necessary to note the shape, position, and inclination of the remaining teeth. On the lower jaw there are two undercuts that require attention: one on the inside above the mylo-hyoid ridge, to be utilized in some cases in retaining the denture; the other on the outside on the anterior surface, which, when the front teeth remain, is to be protected by a strip of soft wax on the cup when taking a plaster impression, so as to avoid injury to the parts.

FIG. 306.



Showing the region of the hard and soft parts as usually found in palates, the shaded lines around S, S indicating the soft parts; H, the hard. In nature these structural differences are not so sharply outlined as is represented in the cut.

Of the points to be noted in an examination, the hardness and softness of the palate and the ridge are the most important. The ridge may be hard and the palate soft, or the reverse may obtain, the latter condition constituting the most troublesome combination of all. An irregular hardness and softness of the ridge sometimes occurs and complicates the difficulties of the case.

The soft parts of the hard palate occupy its posterior third, extending from the median line, and sometimes including it, to about midway down the alveolar ridge. The hardest parts are usually found in the centre of the hard palate, sometimes occupying its entire length

FIG. 307.

FIG. 308.

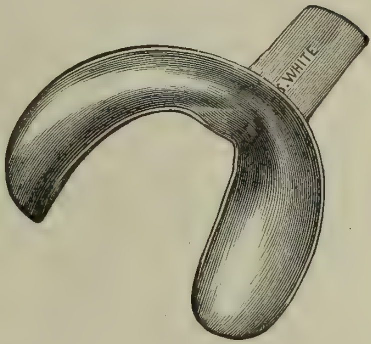


FIG. 309.

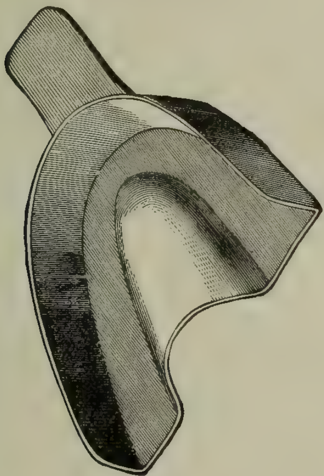
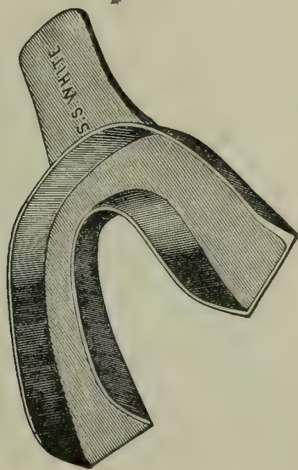


FIG. 310.

FIG. 311.



Impression-Trays.

(Fig. 306, *S* indicating soft; *H*, hard). The inferior alveolar ridge is generally uniformly hard until considerable absorption has taken place. Hence the soft parts of the lower jaw are most marked in elderly subjects.

In cases in which dentures have been worn with too much bearing on the front teeth the anterior portion of the ridge is quite soft and yielding, the osseous portion having been more or less absorbed by pressure.

Impression-Cups.—Taking an impression involves the use of a material with the requisite properties, and a suitable cup to convey it to the mouth while soft and retain it in position until it has the necessary hardness. For convenience of description, an upper cup consists of palate, rim, floor, heel or rear, and corners; the lower cup has no palate, and its inner rim may be called the flange. In order to obtain the best results with any substance the impression-cup must conform to the size and shape of the parts to be copied, with a uniform space of about two lines around the ridge and in the palate for the material. Very rarely is a cup so well adapted to a case that it cannot be improved by bending it with pliers or by otherwise reshaping it. Full upper cups (Fig. 307) have been improved by a raised edge across the rear, designed for the same purpose as the strip of wax described in this article. It will be readily seen that a strip of wax, which is so easily adapted to the parts, is much superior to a raised edge of metal, which, unless it fits exactly, will unduly and unequally press and stretch the soft parts out of place.

As success in taking an impression depends largely on a suitable cup, it is necessary to have an assortment of the various kinds sufficient to meet all cases. A complete set of twenty cups should be divided as follows: Six for full upper cases, three for full lower, three for partial upper, five for partial lower, and three lower with flat floors to take wax impressions for articulating models. If any of the upper cups have high palates, it will be necessary to have more than six. For several reasons, to be given in their proper place, it is better to have all upper cups with low or medium palates. Cups made for lower partial cases have the anterior portion of the floor elevated, and enough cut out to allow the passage of the front teeth. This opening must be large enough to admit the teeth and give room for the impression material. Different cups adapted to from four to ten teeth will be required (Figs. 307–311). For some cases lower partial cups may be decidedly improved by cutting the front entirely away, leaving the handle attached to the inner rim or flange.

Principles and Methods.—The subject of taking impressions derives its importance from the nature of the principles underlying the retention of artificial dentures and the nature of the obstacles to be surmounted in attaining success in this department of dental mechanics. The necessity of a perfect impression appears most clearly in those cases in which the best adaptation and strongest possible adhesion barely attain to or fail of success, owing partly to the limited extent, but chiefly to the unfavorable shape, as well as the hardness and dryness of the parts which are covered by the plate. But even if these difficult cases are excepted, accuracy in each stage of the process, and not a little skill and judg-

ment, are required in taking an impression to secure uniform success in the majority of cases; and though many failures in constructing dentures are due to careless and unskilful work, it will doubtless be admitted that most failures result from an imperfect impression or from some change in the shape of the plate. Generally speaking, neither the model nor the plate can be an improvement on the impression, and too frequently both the model and the plate show the retrograde steps from an impression which was perfect.

In order to determine precisely what should be accomplished by the impression, it will be necessary to touch briefly on the forces which retain and detach atmospheric plates.

1. Absolute contact and uniform pressure produce the most perfect and permanent adhesion of a superior denture. But as a plate under atmospheric pressure sinks more or less into the tissues, it should be so constructed that at first it rests lightly on the palate and bears heavily on the alveolar ridge. Strength of adhesion depends partly on the extent of surface, but chiefly on the shape of the ridge and the relative and moderate softness of the palate.

2. A denture is detached when there is sufficient movement to admit the air at any point around the margins of the plate. Movement of the plate under comparatively light pressure applied at the sides or front generally implies yielding of the surfaces against which it rests. And this yielding is caused either by the relative softness of the ridge or hardness of the palate.

Absolute contact is secured by a good impression taken in the ordinary manner, but uniformity of pressure in the majority of cases must be attained by other means.

1. In cases in which the parts are comparatively and uniformly soft or yielding a perfect impression with a shallow vacuum-cavity, chiefly to relieve pressure on the centre of the palate, is all that is required to secure the best adaptation and adhesion of a superior denture.

2. But the best possible adhesion, and especially capacity for resisting force applied to the sides and front of a denture, do not generally result from an impression of the parts as they are, but require in addition compression of the soft tissues. The methods of producing compression will be given in the proper place. It will be sufficient to state here that the soft parts are compressed either directly by the impression taken in a suitable cup or indirectly by scraping the *hard parts* from the *impression* and the *soft parts* from the *model*.

The fact that in a majority of cases these principles do not require the same degree of attention makes it all the more necessary that they should be borne in mind, so as to be available in the less frequent but more difficult cases which require all the resources of dental mechanics as well as the highest skill of the operator.

In regard to impressions in general, the late Prof. Buckingham remarks: "But no matter what material is used, we can never get two casts alike of the same mouth from different impressions taken at the same sitting." This apparently proves that it is almost if not quite impossible to take a perfect impression; but it really proves, as can be shown by experiment, the unequal compression of the soft tissues; and it

demonstrates the importance and advantage of having methods that will produce definite and uniform results. Heretofore, writers and practitioners have differed, and still differ somewhat, on the consistency of impression-material and the amount of force allowed or required in taking an impression; and there still seems to be some difference of opinion, not to say confusion of ideas, on the subject of compressing the soft tissues, some mistaking displacement for compression, and others thinking that the more nearly a liquid is the impression-material the better.

To show the extent of this difference of opinion, and to give a specimen of the flimsy theories once advanced and still held by some, it will be sufficient to state that at the present time some operators object to plaster, because, as they claim, it will not compress the soft tissues; while it was formerly taught by one of its leading advocates that, as compressing the soft tissues was the chief danger, the plaster must be about as thin as water, and that it was next to impossible to obtain a good impression without fixed resting-points in the cup, because without them it could not be prevented from moving and rocking. It followed, then, that if thin plaster was held lightly against the parts, and neither the impression nor the model scraped to relieve or produce pressure, and a rocking plate resulted, the cause must of course be in the unsteady holding of the impression while setting. Though this may be the cause in some cases, it is almost needless to remark that the real cause of the tilting and dropping of the plate is in the fact of its resting too lightly on the soft parts and too firmly on the hard parts of the palate.

As has already been stated, the soft parts are found on the posterior third of the hard palate, and sometimes on and around the alveolar ridge. These parts, especially when very yielding, will be compressed to some extent even with softest material. This can be shown by touching the parts very lightly with the finger or with a broad-ended instrument. It is not possible, therefore, even if it were desirable, with any material of the proper consistency, to avoid all compression; and as this compression must be uniform, nothing can better meet the requirements than a soft or plastic material that is less yielding than the tissues to be compressed. And, besides, this is the only certain method of limiting compression—a point that must not be overlooked; for if the compression is carried too far, the plate will be detached by the tissues acting as a spring. The softness of the tissues and the extent to which they should be compressed will therefore determine to a great extent the *consistency* of impression-material.

Impression-Materials: Essential Qualities.—The two general and most obvious properties required in an impression-material are —the necessary softness for taking the impression, and the proper hardness for retaining its shape when being removed.

The essential properties are the following: It must take a sharp imprint, must remain where placed, must harden promptly, and when there are undercuts or dovetail spaces it must either bend or break with moderate force. All materials must not only have these essential qualities, but they must be available under the conditions existing in the oral

cavity; and, besides, they must have no qualities which are repulsive to the patient.

The material must be soft enough to copy the finest lines of the mucous membrane, and at the same time must have that consistency which will compress without displacing the soft tissues. "Remaining where placed" implies that the material must not only have no tendency to warp or fall away of its own weight, but that it must have the least degree of expansion or contraction. The property of hardening is as essential to the removal as that of softness is to the taking of an impression. When there are undercuts or dovetail spaces no correct impression can be withdrawn without either bending or breaking; and any material must yield or fracture with moderate force, or too much pain and injury will be inflicted. As the taking of an impression is generally an unpleasant process, and sometimes not a little painful to the patient, it should be taken in such a manner as to give the least degree of pain and annoyance.

Materials.—The impression-materials are wax, gutta-percha, modelling compound, and plaster of Paris. The two latter, having the greatest number of desirable properties, are the most extensively used. Wax was the first, and for a long time the only, material in use, and it is still employed to some extent for full and partial cases, and almost exclusively for taking impressions for articulating models. It also serves a most important purpose in reshaping and building up the rim, and especially the palatine portion, of the cup when taking plaster impressions. It is one of the most useful substances in the laboratory. It has most of the essential qualities. Though it can be made plastic enough for many cases, it often stretches and displaces the soft parts; but it does not take so sharp a copy as plaster or modelling compound, and, unless properly supported by a cup with a high rim and palate, it cannot be properly kept against the parts or will be bent or warped in taking it from the mouth. It hardens sufficiently, especially when ice is applied to the under surface of the cup, though when there are undercuts or teeth with narrow necks dragging or bending is unavoidable.

Since wax does not flow when soft nor break when hard, great care is required both in taking and withdrawing an impression. It can be made as hard as is consistent with its safe and not too painful removal. White wax, being harder than yellow, does not bend so readily; it is, however, more difficult to soften, and requires more force to imbed the parts in it, and is therefore liable to displace the soft tissues. A mixture of yellow wax and paraffin has some positive merits, because it softens at a lower temperature, can be made more plastic, and when cool is much harder than wax alone.

Gutta-percha has been and is still used to a limited extent for taking impressions. It can be made both softer and harder than wax, and will therefore take a sharper impression, and not only hold its shape better, but it is claimed that because of its elasticity it will after withdrawal tend to resume its original form. But it has too much contraction to be reliable as an impression-material. Prof. Austin has constructed cups from it which are excellent for many partial cases. When

used the model should be run as soon as it is taken from the mouth, to anticipate contraction as far as possible.

Modelling compound is the latest, and in some respects one of the best, materials for taking many partial and full lower impressions. It "is composed of gum dammar, stearine, French chalk, with carmine to color it and a perfume to render it pleasant. Four varieties are manufactured—the soft, the medium, the hard, and the extra soft, differing as to the quantity of stearine and chalk incorporated with the gum."

Methods for Wax and Similar Materials.—The most general directions which apply to all that can be given for the use of these materials are the following: As to quality, they must be pure or properly combined; as to quantity, there must always be a little surplus and a uniform thickness; and these materials must in all cases be securely anchored to the cup by warming the adjoining surfaces over a spirit-lamp. The neglect of this point accounts for the general dragging of large parts of the impression that is sometimes complained of when using modelling compound. The rim of the cup for these materials must be a little higher than for plaster, because they require considerable pressure to imbed the parts in them, and not a little support while hardening; and they require the protection of a high rim when being withdrawn from the mouth. And, as these substances do not flow when soft nor break when cold, they must be placed on the cup to conform somewhat to the shape of the mouth and be pressed into position, and withdrawn on a line with the ridge or remaining teeth. Much of the local dragging around the teeth and in the interdental spaces is caused by want of care or skill in removing the impression.

When we come to the details of manipulating these materials it will be found that they require a little different management. Wax should be made as soft as possible without bringing it to the melting-point. It can be softened with either dry or wet heat, but when the latter is used the moisture should always be absorbed from the surface with a towel before manipulating with the hands. If this point be observed, there will be no occasion to complain of want of cohesion in any of these substances. Modelling compound is most readily softened by placing it in water which has been brought to the boiling-point. When it is quite soft take the mass from the water and place on a towel or napkin, and remove all the moisture before working it with the hands. When ready for the mouth all these substances should be held a moment over a spirit-lamp and then placed in a warm cup.

After selecting and shaping the cup the condition of the oral secretions must be noted. Their absorption or removal by other means is often required in order to secure the greatest degree of smoothness and accuracy of the impression. And even though plaster absorbs the moisture, the condition of the oral fluids demands special attention when using that material. When the secretions are abundant and the mucous membrane is very soft or spongy, the mouth should be dried with a soft napkin just before introducing the impression-cup; and it is often necessary in such cases to use an astringent or other kind of mouth-wash for some time, in order to put the mouth in the best condition. Dilute phénol sodique has been recommended for this purpose, and, according

to the writer's experience, this is a most excellent remedy. If the secretions are thick or viscid, the mouth should be rinsed with a solution of alum or salt.

The mouth being in proper condition as regards the secretions, the position of the patient as well as that of the operator next demands attention. The operator should stand to the right or a little back of the patient, who should sit upright in a common chair. The patient must be directed not to open the mouth too wide, but only wide enough to admit the cup and contents. To introduce the cup, especially when the mouth is small and the jaw wide, requires no little care, so as to avoid injury to the parts. The right side of the mouth is pressed away with the corner of the cup, while the left side is distended with a finger of the left hand, when the cup is readily passed in, adjusted to the ridge, pressed up evenly and firmly until the parts are imbedded. Now direct the patient to draw down the lip, and then with the finger produce external pressure all around the rim, keeping firm and steady force against the tray. External pressure around the rim is particularly important in cases having undercuts or depressions.

The necessity for direct and steady pressure is based on the fact that these substances will not flow and are liable to displace the soft tissues. These substances can be hardened by holding a small napkin dipped in ice-water, or a piece of ice folded in a napkin, against the under surface of the cup; but in most partial cases care must be taken not to make the impression too hard or the parts will be injured by its withdrawal. Unlike plaster, these substances do not adhere to the membrane, and there is no necessity for such promptness in detaching the impression as when plaster is used.

Generally speaking, the more perfect an impression the more difficult its removal, because of atmospheric pressure. This is overcome by admitting air between the impression and the membrane, which is done by raising the lip and cheek at the front and sides and elevating and depressing the handle of the cup by short, firm movements. Or the soft palate may be raised and the air admitted at the back part of the impression. The air is best admitted at this part by directing the patient to give a slight cough or expel the air forcibly from the lungs. When detached from the membrane it must be removed with great care, the direction being determined by undercuts, the projection of the anterior portion of the alveolar ridge, and the position of the remaining teeth.

As regards the use of these materials in full upper cases, there always exists the probability of imperfection from bending or dragging; and in cases having undercuts or projections there is an element of uncertainty which cannot be ignored; so that, except for special reasons to the contrary, plaster should be used in all such cases. These special reasons include, as regards the patient, excessive sensitiveness or irritability of the soft palate, or prejudice against plaster or aversion to it from knowing of cases where it has been improperly used; and as regards the operator, inexperience or want of skill in the use of this valuable material. It may be remarked here that irritability of the soft palate is scarcely a sufficient reason for not using plaster, since

such a condition of the parts can easily be removed by the proper remedies.

Full Lower Impressions in Wax or Modelling Compound.—The methods for taking full lower impressions are in general the same as for taking full upper ones. The cup should conform to the height and thickness of the ridge, and its flange should correspond to the depths of the parts to be taken; and when there is an undercut the edge should be turned in to secure pressure against the wax while it hardens. When the cup and contents are properly adjusted to the ridge, and before being forced down, the cheeks should be pressed away to prevent folds of the mucous membrane from being caught between the cup and ridge, and the patient be then directed to raise and thrust forward the tongue, to allow of the parts being taken to their full depth. When the cup is in position the tongue may be drawn down again to assist in pressing and keeping the wax against the parts. To press down and hold the cup in position place the thumbs on the cup in the region of the bicuspids and one or two fingers on each side under the jaw.

Upper and Lower Partial Impressions in Wax and Modelling Compound.—For taking partial impressions wax and modelling compound have many desirable qualities. The latter has all the good properties claimed for gutta-percha, with none of its objectionable features. It can be made as soft and hard as gutta-percha, without its stickiness and contraction.

The obstacles to be overcome in taking a partial impression are the undercuts and the narrow necks of the teeth with the resulting dovetail spaces. As before remarked, no material can be used in such cases which does not either bend or break. The essential points in using these materials are—first, sufficient softness; second, properly-directed force; third, careful withdrawal in a line with the axis of the teeth. The chief point, after all, is to confine the drawing or dragging as closely to the teeth as possible. The general dragging of the material away from the cup can easily be prevented by applying dry heat to both surfaces, but the local dragging is unavoidable, and if kept within proper limits cannot be regarded as a great disadvantage, since no plate can fit closely around the necks of teeth with relatively large crowns. Yet, as all these substances must have a certain degree of softness to make withdrawal possible, it is difficult to limit the dragging or bending.

Plaster of Paris.—Plaster of Paris, or gypsum, is a calcium sulphate ($CaSo_42H_2O$) which is prepared for dental and other purposes by being pulverized and calcined. Exposure to heat drives off the water of crystallization, which mixing again supplies, restoring the plaster to its original condition of solidity. It is claimed that if the proper quantity of water be taken the plaster will be almost as hard as the original gypsum. Only the best quality of plaster should be used for dental purposes, and, as all its desirable properties are damaged by exposure to moisture, it should be kept in a dry, warm place. Assuming that the plaster has been properly prepared and has not been exposed to moisture, there is one essential condition that must be complied with to obtain the best results: it must be properly mixed. Of the several

methods of mixing plaster, that is best which most perfectly excludes or removes all air-bubbles, prevents expansion, and, when used for that purpose, gives the sharpest and smoothest impression. When mixing plaster the following points, which any one can easily test by experiment, should be borne in mind: (1) Plaster mixed very thin or very thick or stirred too long will set soft and expand decidedly, an excess of water, plaster, or stirring interfering with perfect crystallization; (2) though coarse plaster sets hard, it expands too much for dental purposes; (3) substances used to hasten its setting always soften plaster, and should be used for impressions only; (4) plaster sets most perfectly and promptly in warm water.

The best vessel to mix plaster in is a small bowl, for the reason that in such a vessel the mass can be stirred more quickly and thoroughly. The air which is always found in plaster should be freed before the latter sinks into the water. It is almost needless to say that this cannot be done by pouring the water on the plaster, but can best be accomplished by *sprinkling* the plaster into the water. Plaster will usually be found more or less packed in the can or barrel, and should first be loosened up to free the air from the mass, and then sprinkled into the water by tapping the spatula on the edge of the bowl, which may at the same time, and also while stirring the plaster, be jarred on the table. Sprinkle in the plaster till all the water is taken up, or, when sufficient plaster has been added, pour off the surplus water. The stirring should be brief, rapid, and thorough.

Prof. Henry Leffman contributes the following points on the chemistry of plaster:

"The setting of plaster is a chemical process, the water being taken up in the proportion of two molecules to one of the calcium sulphate; that is, $CaSo_4$ becomes $CaSo_4 + 2H_2O$. The facility with which the combination occurs depends largely on the care which has been taken in preparing the plaster. If it has been too highly heated, the power of taking up water is lost. The presence of impurities also of course interferes with the setting qualities. It is well known that many saline substances—*e. g.* common salt—hasten the setting, but the exact cause of this is not definitely known. In the case of common salt a double composition occurs to a slight extent, by which calcium chloride and sodium sulphate are formed. When a solution of the so-called liquid silex, which is sodium silicate, is put on a plaster cast, a similar reaction often occurs, forming sodium sulphate and calcium silicate, and the sodium sulphate appears on the surface of the cast in white moss-like tufts.

"The hardening of calcium sulphate is attended by the production of heat and by increase of bulk. The best casts are of course obtained when the mixture with water is made thoroughly, so that every particle of plaster has an opportunity to absorb the proper amount of water."

Of the various substances that have been used to hasten the setting of plaster for impressions, common salt is the least objectionable and answers every purpose. From five to ten grains is the proper quantity for the average impression. To secure uniform diffusion, throw the salt

into the water before sprinkling in the plaster. Salt hastens the setting, makes the plaster brittle, and, it is claimed, reduces its expansion, each effect being a decided advantage when taking an impression. If salt really prevents expansion, it is a most valuable addition to the plaster. The brittleness induced by salt lessens the amount of force required in fracturing undercut and partial cases.

Objections to Plaster.—Plaster is disagreeable or difficult to use in proportion as its qualities are disregarded or it has not been kept within proper limits. And, because it will not readily accomplish everything, some who have not used it properly or but for a short time seem inclined to replace it by the materials which, though apparently requiring less skill, are seldom or never so reliable. As many objections to plaster, and much prejudice against it, come from using it improperly, it will be necessary to enter into some perhaps apparently unimportant details in describing methods which secure the desired results with the least annoyance to the patient and the best chances of success to the operator. The too common plan of taking a cup that will simply enclose the ridge, paying no attention to the height of the palate, and piling the plaster high in the centre, is a good way to choke the patient, spoil the impression, and furnish a strong argument against plaster. And having it mixed so thin that it will drop on the patient's clothing, or so thick that the parts cannot be imbedded, or using such a quantity that there is an overflow into the mouth and fauces, are mistakes that are certain to cause failure and loss of reputation.

A Perfect Impression, and its Test.—A perfect impression must have fulness, smoothness, and sharpness. It should cover a little more surface all around than the finished base-plate, faithfully reproduce all the finest lines, and should be as smooth as the mucous membrane. The sharpness is required not only to attain the best adhesion, but to counteract as far as possible the blunting effect of cast-varnish. Smoothness is necessary to the health of the surfaces against which the plate rests.

A full impression adheres to the parts it covers, either because the air is excluded from under it, or on account of alveolar undercuts, or because by being left in too long it has absorbed the moisture from the mucous membrane. The latter effect is generally due to ignorance or carelessness, and usually injures the mouth. The resistance which results from pressure of the atmosphere against the under surface of the cup, showing that the air is excluded above, can always be relied on as the *certain test of a good impression.* The resistance which is offered by an undercut can easily be distinguished from that of the atmosphere, and is nearly always felt after the latter is overcome. Of course it is admitted that an impression which drops when touched or is detached with very little force may be so modified as to produce a plate with fairly good adhesion; but such an impression cannot be considered reliable in any case, and in difficult ones it is almost wholly worthless.

Methods of Taking Plaster Impressions.—The best attainable results with plaster are secured when the required quantity of properly-prepared plaster is placed in a cup exactly adapted to the case, and pressed up with the rear slightly in advance of the front. The only objection to passing up the heel of the cup in advance is the liability of confining air

between the plaster and the palate. Theoretically, this seems to be a strong objection, but practically it amounts to very little. And even when air is so caught the defects appear on top of the rim, usually above the plate-line, being carried there by the outward flow of the plaster.

When the soft palate is too irritable to permit contact without retching, local or constitutional treatment should be resorted to before attempting to take the impression. Perhaps the best local treatment consists in manipulating the parts with a feather or with some suitable instrument. As a constitutional remedy some operators recommend bromide of potassium, which should be administered about an hour before taking the impression. Local applications of cocaine will also diminish the irritability of the parts. But even when the soft palate is sensitive, retching can generally be prevented by keeping the plaster on the hard palate, which is done by having a line or ridge of wax across the heel of the cup. The plaster can be kept in front of this line in most full and all partial cases, thus copying the surface very little farther than it will be covered by the plate. It is the writer's opinion, based on his experience, that if this method of protecting the soft palate, and at the same time keeping the plaster out of the mouth, is properly applied, treatment of any kind will very seldom be required. This method and its other advantages will be described in detail.

Special cases sometimes require such extensive cutting away of the rim or floor of the cups as to render them unfit for further use unless these parts are restored with wax or modelling compound. When necessary, never hesitate to sacrifice a cup if by that means a more perfect impression can be obtained. The rim of the cup must not be so high as to stretch or displace the soft parts connecting the cheek with the ridge. When the ridge is short or low, the rim of the cup must be narrow. The two worst faults a cup can have are to be too narrow at the rear and too high in the palate. The ridge—or, in partial cases, the ends of the teeth—should always rest on or almost touch the floor of the cup, because in that way even a nervous hand can hold the impression steady. As a general rule, the plaster should have least body or thickness where the parts are most yielding, in order to secure positive and uniform compression.

In view of the many ill-adapted cups in use, and the excessive quantity of plaster often employed, it is somewhat remarkable that serious accidents do not frequently occur in attempting to take plaster impressions. The most important rule that can be given for the use of plaster is this: *keep it on the cup*. In order to do this it must not be mixed too thin, the proper quantity must be taken, and its flowing or being forced into the mouth must be prevented. When introduced into the mouth the plaster should be so stiff that it will not drop from an inverted cup. When the cup is made to conform to the size and shape of the parts, the quantity of plaster, which is thus reduced to the minimum, is easily estimated. As the palatine portion of very few cups can be so bent as to conform exactly to the roof of the mouth, a wax impression of the palate should always first be taken, a layer removed to give room for the plaster, and a line left intact across the

rear to limit its flow. In most undercut and all partial cases this wax palate must be securely attached to the cup by warming the adjoining surfaces with dry heat, and the plaster must be anchored to the wax by undercutting the latter and chilling it in cold water. If any of these points are neglected, the cup and the wax or the wax and the plaster will part company, and failure will almost certainly be the consequence.

The advantages of a wax palate, given at length and in their proper order, are these: (1) It measures the height and gives the exact shape of the parts, thus enabling the operator to estimate the proper quantity of plaster; (2) it makes the taking of the palate a certainty, with the least risk of the plaster being pressed against the soft palate or falling into the mouth; (3) it aids in adjusting the cup, which should always be pressed up with the second finger in the centre; (4) it secures uniform compression of the soft tissues; (5) by being scored and undercut it anchors the plaster securely to the cup. And, besides these advantages, this wax palate when softened enables the operator to remove the model and the impression from the cup together. Each of these is an important point, and the last is not least, since it is the only reliable method of separating undercut and partial cases. This simple and efficient method of taking all upper impressions, full and partial, needs only to be tested to be adopted, but all the points must be noted and complied with or it will not prove satisfactory. If the cup be prepared in this manner, there will be no occasion to use cups with movable palates to press up and anchor the plaster, nor will it be necessary to make dies and swage cups for special cases.

The extent of the space between the cup and roof of the mouth will determine the mode of procedure. If this space is less than one-fourth of an inch, place a strip of wax about half an inch wide across the heel of the cup; if the space is more than one-fourth of an inch, take a wax impression of the entire palate. In both cases make the wax quite soft, and, being sure that the cup is in proper relation to the parts, press up until the floor touches the ridge; remove and trim away from the wax a layer of about one-eighth of an inch to give room for the plaster. In all cases a ridge of wax two or three lines wide should be left across the rear. This, by running the plaster to an edge and limiting its flow backward, thus forcing it against the palate, constitutes one of the best methods that can be devised for compressing the soft tissues.

After preparing the cup and having everything at hand some points remain to be noted and certain directions must be given to the patient. As already directed, note the condition of the oral secretions. It is almost always some advantage, and often a necessity, to rinse the mouth with a solution of alum or salt. When the mucous membrane is soft, spongy, or diseased from the previous wearing of a plate, a tonic and astringent mouth-wash should be used for several days or weeks before taking the impression.

The patient should be directed to avoid swallowing while the cup is in the mouth, but the breathing may be safely allowed to take care of itself. As soon as the cup is in the mouth request the patient to lean the body and the head forward, and when the cup is in position to draw down the lip. If the cup has the proper shape and the right quantity

of plaster has been employed, it is not specially necessary for the patient to lean forward, but nothing can press the plaster against the ridge all around at the same time so evenly and positively as drawing down the lip. In addition to this, pressure with the fingers may be made at the front.

Never attempt to remove a full impression until the plaster will fracture without crushing. A partial impression may sometimes be started a little to loosen it around the teeth and enlarge their imprints before it reaches that degree of hardness, though there is generally a more excellent way. By pressing between the thumb and finger plaster that has just reached the fracturing-point, it will be seen that it can be easily crushed. To know when it is hard enough, test the plaster in the bowl, or, better still, the surplus which has flowed over the front of the cup, as this more truly represents the condition of that in the mouth.

When the cup is properly shaped place the plaster around its floor, making it thin on the palate, high at the corners, but highest in front; so that when pressed up the surplus will be forced over the rim and not back into the mouth. In this way the plaster is placed just where it is needed, and the worst annoyance to the patient is prevented. The manner of introducing the cup into the mouth is the same as for other materials, but when using plaster more care is necessary to avoid displacing it with the lips or remaining teeth. The mouth should be opened just wide enough to admit the cup and contents, so as to allow of its greatest lateral distension. This is especially necessary when the mouth is small and the jaw relatively wide. The right side of the mouth is pressed away with the corner of the cup, the left side distended with one or two fingers of the left hand, when the cup is passed in, and then with the second finger in the centre and the rear a little in advance it is forced up with firm and steady pressure until increased resistance shows that the ridge has touched or almost touched its floor. Now request the patient to draw down the lip, when pressure can be made with the fingers at the front above the rim of the cup. While the plaster is setting the cup must be held perfectly steady, the least movement being liable to damage the impression.

An impression usually hardens in three or four minutes. It should be so hard that it cannot possibly crush, but it must not be left in so long that by absorbing all the moisture it will adhere to the mucous membrane. As there is a degree of softness which produces the best impression, so there is a degree of hardness which allows of the easiest and safest withdrawal. As before stated, the most reliable test of a perfect impression is the resistance to its removal. Many full upper impressions will adhere with decided tenacity, and will sometimes resist even forcible attempts to dislodge them. Though a plaster impression when set must be removed promptly to prevent its adhering to the membrane, yet nothing results from too much hurry or from applying an undue amount of force except pain to the patient and damage to the impression. By raising the lip and the cheek at the front and sides to admit air, and so break up the adhesion, and at the same time elevating and depressing the handle of the cup by short rapid movements, the impression is easily and safely detached. In case of difficulty the air

may be admitted at the rear of the cup by pressing up the soft palate with the finger or the end of a blunt instrument; or the patient may be directed to give a slight cough, which, by raising the soft palate, admits the air under the impression. In some cases, which fortunately are rare, it will be necessary to detach the impression the moment it can be done without crushing; otherwise the moisture will be absorbed, and the membrane, by adhering to the plaster, will be more or less lacerated.

Plaster Impressions for Partial Upper Cases.—As a general rule, partial impressions are most difficult, no matter what material is used. In respect to the obstacles to be overcome, partial cases can be divided into two classes: first, those with short teeth having little or no constriction at the neck and standing in the normal position; second, those with long teeth constricted at the neck, and with either an inward, outward, or lateral inclination, and enclosing dovetail interdental spaces. The difficulties in taking an impression of the first class are easily overcome, and do not increase to any extent with the number of spaces. The obstacles presented by the second class exist even with the loss of one tooth, and of course greatly increase with the number of spaces and the inclination of the teeth.

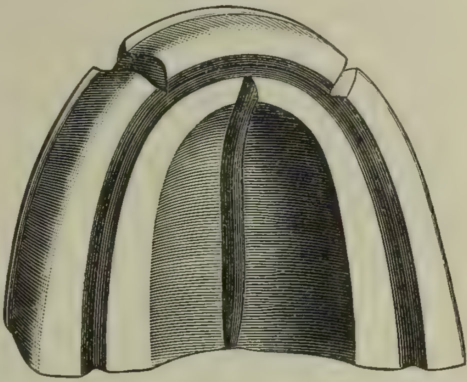
Of partial cases in general it may be observed that the obstacles they present are found on the ridge; and however important it may be to have this correctly represented, it is still more important to obtain a perfect impression of the palate, for the obvious reason that on this the plate has almost all its bearing. As the upper teeth when short or in normal position tend slightly outward, there is generally no difficulty in obtaining a correct and unbroken impression of the entire palatine surface; but in many cases of the first class above referred to, and all of the second, the ridge portion of the impression must yield or break, and that, too, without regard to the material. The rim of the impression must be so thin as to be broken with moderate force, yet not too thin, or the breaking will be too complicated for replacement of the fractured pieces.

It has been truly said that no one material can possibly be equal to the varying conditions of the parts to be covered by, or that are in relation to, the plate. This, though said of full cases, applies also to partial cases. Success in taking partial impressions in general will be found to depend on keeping the dragging or bending close to the teeth, confining the fracture to the rim, and removing the palatine portion intact. Of course many partial impressions can be withdrawn without either yielding or fracture. When plaster alone is used, the palatine part as well as the rim often leaves the cup, or it requires too much force to fracture the rim, and not unfrequently the fracture is too complicated; while if wax or a similar material is used the dragging or bending is so great that the impression is entirely unreliable. It may be safely affirmed that in all partial cases a combination of wax and plaster more perfectly meets the requirements than any one material.

But before giving the details of combining these materials the methods will first be described of using plaster alone and removing the impression in sections. A good method of this kind consists in cutting a vertical groove, after detaching the cup, in the plaster over each

canine eminence, a deep and rather wide groove around the centre of the ridge, and sometimes one, and occasionally two, grooves from before backward through the palate, and then fracturing and removing the impression in sections and carefully replacing the pieces in the cup (Fig. 312). No varnish of any kind should be used to attach the broken pieces, care being taken that not the smallest particle of plaster is between them, that they may be adjusted with the greatest exactness.

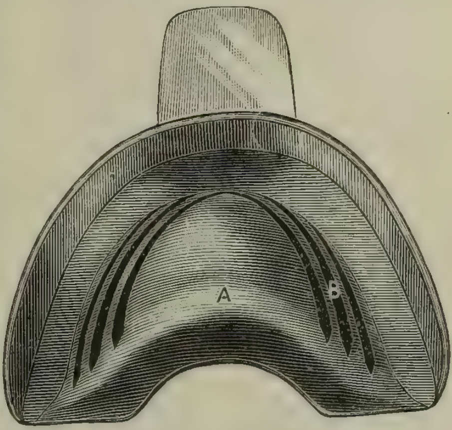
FIG. 312.



Sectional Impressions. This figure clearly indicates where the grooves must be cut in the under surface of the impression after removing the cup. Sometimes two grooves must be cut back through the palate.

Methods of Combining Wax and Plaster.—The wax forms part of the cup or part of the impression, or both, and is sometimes used for cut-offs to anticipate and direct the fracture. First, it forms part of the cup when it builds up the palatine portion, and serves as an anchorage for the plaster, as in Fig. 313. Second, it forms part of the impression when it surrounds the necks of the teeth or is placed against the side of a tooth which has a lateral or inward inclination. Third, it forms part of both when it builds up the palatine part of the cup and extends through the plaster and around the teeth. The cut-offs are wedge-like pieces of wax placed on the inside of the rim of the cup where it is desired the impression shall fracture (Fig. 314). Of these different ways of combining plaster with wax, it may be said that the first is always an advantage, and often a necessity; the second is not a little troublesome, and should not be resorted to except in cases which cannot be managed by other means; the third is a decided benefit in many cases, overcoming as it does one of the strongest objections to plaster—the undue force required to produce fracture.

FIG. 313.



Cup prepared for Ordinary Partial Impressions. This cut shows the cup with a wax palate, which has a raised edge (A) across the rear, and undercuts (B) to anchor the palatine portion of the impression.

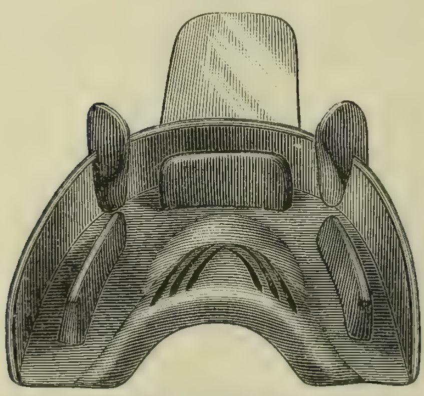
In taking partial impressions with wax and plaster, when the former forms the palatine part of the cup proceed as in full cases, giving special

attention to these points; attach the wax securely; remove a little more from its surface than in full cases; make deep undercuts near the floor of the cup (Fig. 313); and place it for a few minutes in cold water. The layer trimmed from the wax should be from one-eighth to one-fourth of an inch thick, and should taper toward the rear, that the plaster may run to an edge at or just back of the plate-line. As in full cases, leave across the rear a line of wax, which first touches the palate, and then, as the front of the cup is pressed up, prevents the flow of the plaster backward and forces it against the roof of the mouth. Neglecting *to anchor, undercut,* and *harden the wax* will be certain to cause failure. When wax and plaster are combined in this way the rim generally consists of plaster, which will nearly always fracture, and must be afterward accurately replaced in the cup. The rim must not be too thick, or too much force will be required to produce fracture; nor too thin, or the fracture will be too complicated.

Another method, and a most excellent one, consists in first taking a full wax impression, and then replacing a layer taken from its surface with plaster and returning it to the mouth. A modification of the last method but one is sometimes required when only the upper front teeth are to be replaced, the process being much absorbed and the remaining teeth, molars and bicuspids, being elongated or leaning slightly inward. The cup for such a case is prepared by cutting off the rim except in front, so that the plaster will be inside the teeth, which will thus admit of being forced outward a little when withdrawing the impression. Of course the plaster must be anchored to the cup as before directed.

Placing the wax cut-offs already alluded to on the inside of the rim of the cup, and extending them above it, will cause the rim to fracture in large pieces. It is essential that they extend above the rim where the plaster is the thickest, and that they run to an edge where they touch the teeth or the ridge. These cut-offs can also be placed on the floor of the cup, extending up into the spaces and running to an edge, so as to cause the plaster to fracture just where it would be cut in removing an impression in sections, as in Fig. 312. Wax for this purpose can be prepared and kept ready by cutting or pressing it into long strips of the shape of a thick-backed knife-blade (Fig. 314). As will be readily seen, this method anticipates the fracture just where it is most likely to occur.

FIG. 314.



Sections made by Wax Cut-offs. The strips or blades of wax shown on the cup in Fig. 314 are intended to cause fracture just where the grooves are cut in Fig. 312.

But these methods do not always dispose of the dovetail interdental spaces, which are, after all, the most difficult points to manage. Sometimes the most difficult partial cases can be simplified by placing small

pieces of wax against the sides of teeth which lean or are denuded at the necks. This method is well adapted to upper cases. The teeth must be dried, and after the wax is applied the lip or cheek must be held away by the patient or an assistant until the plaster is ready. If the case be such that complicated fracture is unavoidable, a good plan is to fill such spaces with plaster, which when hard must be trimmed smooth and slightly wedge-shaped, and coated with sandarac varnish. The larger end must of course be toward the gum; all thin edges should be carefully trimmed off, and there must not be the smallest undercut. Thus shaped and varnished, these pieces will not be disturbed by the withdrawal of the impression, and can be easily removed by grooving them *transversely* almost to the gum, when they can be fractured without being defaced, and accurately set in their positions in the impression.

This method is better adapted to the upper than the lower jaw, and to cases where the teeth have been recently extracted, for the reason that the plaster cannot extend higher than the necks of the teeth. These pieces can be more easily fitted in their places if they have small shallow and tapering vertical grooves cut in them before applying the varnish. To the objection that this method involves too much time and trouble, it may be replied that it involves much less than taking an impression three or four times or making cups in any manner for special cases. Though it is seldom or never necessary to make dies to swage cups on, yet no time or labor with this or any other method can be called misspent or lost if it makes the difference between success and failure. It will frequently be necessary to build up the rim of the cup at the front with wax in order to carry the plaster up under the lip and prevent the lip from pressing it away or making it too thin. The important point in this, as in all other methods requiring plaster to enter dovetail spaces or deep undercuts, is so to arrange the wax that the plaster will break at the proper places under a force that will not cause undue pain or injure the parts.

Full Lower Impressions in Plaster.—The cup must have the size and shape of the ridge as well as the proper width of rim and length of flange. If either be too wide, the soft parts will be stretched out of place. There is not the same necessity for limiting the flow of the plaster as in upper cases, though an excess cannot be regarded as an advantage. Sometimes it will be necessary to modify the shape of the cup or lengthen the flange with wax or some similar material, and it is often necessary to place a film of wax on a new or a smooth cup to prevent the plaster leaving it. There is often not a little uncertainty in adjusting the cup to the ridge, and unless the proper precautions be taken the tongue will prove an obstacle to taking the parts to their full depths. To take a lower impression, stand at the right side or somewhat back of the patient, adjust the cup to the ridge, press away the cheeks if necessary, request the patient to thrust the tongue upward and forward, and with the thumbs on the cup press it down evenly and firmly into position. A perfect lower impression will sometimes offer considerable resistance to removal, on account of undercuts or atmospheric pressure. If necessary admit the air by drawing away the lip and cheek.

Full lower impressions should be taken with the same care as full

upper ones, in order to utilize atmospheric pressure as far as possible in retaining the denture. Many lower plates can be retained in this manner, especially if the bearing on the centre of the ridge is relieved by placing two or three thicknesses of tin-foil on the model, or by scraping it where the parts are soft, or in some cases passing a "bead" around under the edge of the plate.

In regard to the undercut along the mylo-hyoid ridge, it has been the writer's experience that no material can always be relied on to secure its full benefit in retaining the plate. In several such cases, though the impressions were sharp and full, the models were scraped more than seemed necessary, and though it required a little force to put the plates in position, they did not exert any noticeable pressure and are worn very comfortably. It may be necessary to remark here, for the benefit of routine operating, that an attempt to utilize this undercut when it does not exist or is filled with soft tissue will prove everything but satisfactory.

Partial Lower Impressions in Plaster.—The greatest number of lower partial sets of artificial teeth consist of molars and bicuspids, owing to the tendency of these teeth to decay, as well as to the greater relative durability of the front teeth. Sometimes, however, the incisors alone are to be replaced. An impression in such a case is secured in the easiest and simplest manner without a cup. Mix the plaster as usual, and while holding the lip away proceed with the spatula to fill the space and cover the teeth on either side to the depth of about one-fourth of an inch. The plaster should cover three or four teeth inside, though it is not necessary to extend it so far on the outside. When the plaster has set the impression is best removed by cutting a deep groove along the centre of the ridge about halfway through the plaster, and then fracture it by a turn of the knife-blade. Remove the sections, adjust them nicely together, and build soft plaster in the groove and over the reverse surface of the impression. This method is adapted to cases where there are several spaces not too far apart, especially when near the front of the mouth. When all the molars and bicuspids or molars alone are absent there is usually no difficulty in obtaining a good impression with a suitable cup. Such a cup has the anterior part elevated and sufficient cut out to admit freely all the remaining teeth and give room for the plaster. If the opening is not sufficient for this purpose, it can be readily enlarged with a file or a sharp knife. It will nearly always be necessary to place on the inside of the cup at the front a ridge of soft wax, to keep the plaster out of the undercut on the anterior surface of the jaw. If an impression of this part is required, the wax must still be used and a little room left for the plaster. If this precaution be neglected, difficult and painful withdrawal cannot be avoided. The complications and difficulties of lower cases increase with the length and inclination of the posterior teeth. As the lower teeth generally lean inward—the bicuspids, in addition, sometimes leaning backward and the molars forward—the interdental spaces are nearly always of the dovetail variety. On this account difficult lower impressions are most readily and certainly taken with a combination of wax and plaster. A full wax impression is first taken, and either a

layer removed from its surface to give room for the plaster, or a ring of wax from around each tooth is cut from the impression and returned to its place in the mouth. When these wax rings are nicely adjusted around the teeth remove the remainder of the wax from the cup and fill it with plaster. These wax caps or bands are not so readily displaced as when used on the upper teeth, and they often answer a good purpose around the constricted necks of leaning or elongated lower teeth. Some dentists first take a wax impression and run a plaster model, on which they form wax caps to cover a number of teeth; as, for instance, the six or eight front teeth can thus be capped when they are irregular or lean backward. The convenience of thus making caps on a plaster model is as obvious as the difficulty of forming them, in the mouth, with its warmth and fluids to interfere. Sometimes small pieces of wax—or, better, modelling compound—can be pressed against and tied or otherwise fastened to the undercut side of a long tooth or teeth. These pieces must be so shaped that they cannot be drawn away or out of shape with the impression. Some operators place on the floor of the cup wedge-shaped wax cut-offs, which, when in proper position, cause the plaster to break in the middle of the spaces; or the cup, which has been oiled, can be first removed, the wax taken out, and the plaster detached in sections and replaced in the cup. Unless the wax cut-offs form a part of the impression they can be left out. Another method, which applies to either upper or lower cases, is thus described by Prof. Guilford: "Another good plan that I frequently employ in cases where there are loose teeth or those with constricted necks consists in placing upon the cup and attaching with heat lumps of wax of the proper size and in right position to allow these teeth to imbed themselves in. Before inserting, and while the plaster is being mixed, both the cup and the pieces of wax upon it are kept warm. At the proper moment the balance of the cup is filled with the plaster, and the whole quickly introduced into the mouth. The teeth imbed themselves in the wax, while the balance of the mouth is covered with plaster. The wax is chilled by the cold plaster, but still yields enough to admit of withdrawal without difficulty." It may be added that if the water is warm the objection to the cold plaster will disappear.

II. Plaster Models.

Given a perfect impression, the next important step is to obtain a faultless model. This must have for all kinds of work the sharpness and smoothness of the impression, and besides, for moulded work, it must have the highest degree of hardness consistent with the least expansion, in order to counteract as far as possible the softening effect of the vulcanizing process. And the writer would here add, parenthetically, that this softening effect can be reduced to the minimum by vulcanizing in steam, which is done by propping the flask up out of the water. The decided advantages of this method are most marked in cases that stand over night in the vulcanizer.

As the finished plate is simply a reproduction of the impression, all the fine lines and delicate tracery of the latter must be trans-

fered to the model on which the plate is to be swaged or moulded. To ensure separation from the model and to preserve their sharpness and smoothness plaster impressions must be coated with some liquid substance which, when applied, has no appreciable thickness, will not soften the surface of the model, and will allow the plaster to flow smoothly. Only plaster impressions require a separating fluid. Impressions of wax and similar materials should be dipped in water, as this is more readily displaced by the plaster than is air.

But before varnishing the impression the mode of forming the vacuum-cavity should be determined. It is either cut out on the impression or formed on the model with a piece of soft metal. With the first method there is no risk of displacement or of having holes in the plate by the loosening and dropping of the pins used to attach the metal to the model. First outline the vacuum-cavity with a soft pencil, keeping it at least one-fourth of an inch from the posterior border of the plate-line. If it is not perfectly cut on the impression, it can be trimmed up a little on the model, and in cases where the parts around it are soft a line should be cut close to it with a blunt-ended spatula or knife-blade, so as to produce a raised edge around it on the plate. Unless the impression has been so taken as to press up the yielding tissues, the cast should now be scraped where the parts are soft in the posterior third of the hard palate. In almost all cases a little more compression will be required by the posterior edge of the plate, and sometimes by its entire margin ; the first being accomplished by making a slight shallow bevel two or three lines wide across the heel of the model, at and forward of the plate-line, and the latter by cutting a slight groove around the ridge with a blunt spatula or blade where the parts are yielding, so as to form a " bead " on the plate just under its margin. Such a bead must correspond to the depth of the soft parts, and must be made smooth and nicely polished. If a swaged plate is to be made with the edge of the rim turned out to enclose the tops of the artificial gums, the rim of the impression may be trimmed down to the plate-line, thus leaving a square shoulder on the die. Plates with such a flange are required when single gum teeth are used, and also for continuous-gum work.

Two varnishes, shellac and sandarac, are used on the surface of plaster impressions, and each has its advantages—shellac staining the plaster and sandarac leaving a glossy surface. Shellac is not a parting fluid, being used merely to stain the plaster, and is necessary in all cases which require the impression to be broken away from the model. Sandarac, though a parting fluid, does not admit of easy separation. Therefore, after these varnishes are dry the impression should be again coated with some fluid which will prevent adhesion of the model. Some operators simply saturate the impression in water before running the cast. It is a better and much safer plan to use soapy water. All full cases without undercuts can be separated in this manner. It is well, however, to run the cast as soon as possible after taking the impression, to prevent expansion or porosity in the latter and to prevent crystallization of the salt on its surface. It has been, and still is, the too common practice to oil the surface of the impression. The only thing that can

be said in favor of oil is that it ensures easy separation; but, as there are other substances just as reliable in this respect, there is no good reason for its being used. The objections to oil are that it softens the surface of the model, and that plaster will not flow smoothly over an oiled surface. A parting fluid that answers every purpose is made by dissolving an ounce of any fine soap in a pint of warm water. This should be kept bottled up; a little may be taken out for each case, none of which should be returned to the bottle. Care must be taken to leave none of the soap solution unabsorbed on the surface of the impression or in the imprints of the teeth, as it will cause porosity. In all partial and undercut full cases first use shellac or sandarac, and when dry apply the solution of soap.

The kind of work a model is intended for, swaged or plastic, will determine its size and thickness. For swaged work the model must have that shape and thickness which will permit its withdrawal from the sand and give the die sufficient strength to withstand the blows of the hammer. To secure the required shape and thickness surround the impression with a flaring rim of sheet wax or tin about two inches and a half high; this will serve as a matrix or mould for the body of the cast.

When a moulded plate is to be made, place a strip of paper about an inch and a half wide around the impression, and fasten it at the rear with a pin or a small hand-drill or excavator.

The most desirable quality in a model for swaged work is smoothness, and in addition to this the most important quality for moulded work is hardness. Plaster intended for models should be mixed quickly and poured promptly, that it may be as thin as is consistent with hard setting. If mixed too thin, it will not set hard; and if mixed too thick, it will not reproduce all the fine lines of the impression, nor, in partial cases, flow into the depressions left by the teeth. The best plan is to take a little more water than is needed, and after sprinkling in sufficient plaster pour off the surplus, when, if the surface is too watery, a very little more plaster may be sprinkled in, and the whole mass be stirred rapidly while the bowl is jarred lightly on the table. For partial models the plaster should be mixed a little thinner than for full ones. After being varnished and soaped and allowed time to dry, the impression should be dipped in water before running the model. It is an advantage to have a little pure water in the depressions left by the teeth, as this is displaced more readily than air by the inflowing plaster.

Models in all lower cases and in all partial cases, upper or lower, can be run most easily and perfectly by holding the impression in the hand, and, while dipping on the plaster with the spatula, tapping the cup lightly against the table to settle the contents more thoroughly and drive the air-bubbles to the surface. In other cases, and when the impression is surrounded by the ring already described, pour the plaster quickly from the bowl into the left corner until it runs around the rim and over the palate; then the remainder may be poured in more quickly. Though the pouring must be done promptly, it must not be done so suddenly as to enclose the air. When poured rap the handle of the cup with a horn mallet to settle the contents.

As has been stated, the essential requirement in a model intended for plastic work is the greatest degree of hardness consistent with the least expansion. It is well known that the ordinary plasterer's plaster becomes very solid in setting, and in a great measure preserve its hardness during and after the vulcanizing process. The writer has frequently used this plaster for filling flasks on account of its superior hardness, but laid it aside because its expansion was unfavorable to closeness of joints.

Recently, the expansion of plaster has engaged the attention of several practitioners: among others, Drs. Macleod, Fletcher, and Spence have experimented with a view to determining the best means of overcoming this objectionable property. In addition to showing the expansion of plaster to be quite marked, the experiments of Dr. Macleod seem to prove that the upper surface of a block of plaster is raised or bowed. A block two feet square expanded about five-sixteenths of an inch, and the lower surface was bowed up half an inch in the middle. The same phenomenon, this writer claims, is seen in models, the palatine portion being raised or "domed" up; which, in his opinion, fully accounts for rocking plates. Dr. Macleod finds in potash alum a perfect remedy for the expansion and warpage of impressions and models. The proper quantity is three or four ounces to a gallon of water for taking impressions, making models, or filling flasks. Of alum, Dr. Spence says: "About ten grains to the heaping tablespoonful of plaster gave the best results. I first mix the alum with the water, then the plaster. After some search I found a plaster which would set hard with alum —much harder than without it. But most plasters set soft with it, and *all* softened very much on boiling, and remained so when dry."

Prof. Richardson, referring to the experiments alluded to above, says: "Where Dr. Spence treats of alum as an ingredient of plaster mixtures, he states that its effect is to make most plasters set soft. The particular salt used by him in these experiments was the ammonia alum or sulphate of alumina and ammonia. Mr. Fletcher of England, alluding to this latter statement, says: 'Alum, as properly understood, means the sulphate of alumina and potash (potash alum). Its action with plaster of Paris is totally different from that of ammonia alum, which for years past has been sold in the place of the potash salt to which the name was originally given. A solution of potash alum, boiling hot, instead of softening plaster will make it so hard that it is difficult to cut or break, and it will cause plaster which has totally lost its power of setting to set again, although not sufficiently hard for use.' Dr. Spence in subsequent experiments with the use of potash alum was unable to obtain the results claimed for it."

If, however, Mr. Fletcher's statements should be verified, the ascribed property would give great additional value to alum as an ingredient in plaster mixtures, especially for models used in connection with the vegetable plastic bases, since, according to Dr. Spence, the minimum of expansion being secured in its combination with plaster, and also the maximum of hardness, as claimed by Mr. Fletcher, the best possible results might be anticipated in the cases indicated.

Separation.—After giving the plaster a half hour or more to harden, the next step is separation. Wax, gutta-percha, and modelling compound are made ready for removal by immersing in warm water until quite soft; in full cases the rim is then readily turned down; in partial cases it must be carefully removed from around and between the teeth; after this the palatine portion is easily detached. Great care must be taken that the whole mass of impression-material is thoroughly softened, as when it is left too hard fracture of the frailer portions of the model is apt to occur. Removal of plaster impressions can be effected with safety and certainty only by being broken away piece by piece, and no time or labor is lost which secures a perfect model by this process. The model in full cases, upper and lower, without undercuts, may sometimes be removed by rapping the cup lightly with a horn mallet or the handle of the plaster-knife; but should the model be thin or have much projection, no force of any kind or degree is allowable. When the model is thin or there are undercuts, the cup must first be detached, leaving the impression and the model still together, great care being taken to prevent their premature parting through the application of undue force. To accomplish this, soften the wax under the impression, and, holding one or two fingers under the cup and the thumb on top of the model, thus keeping them together, pass a rather long and narrow knife-blade through the wax, starting at the heel and passing almost to the front of the cup, and either gently turn the blade, or, using the heel of the cup as a fulcrum, press down until the front of the model is seen to rise. If the blade has a wedge-like shape, the cup will be loosened by passing it in once along its floor on either side. By neglecting to hold the model against the impression the teeth on a partial model, as well as the front of a thin full model, will be fractured. If the rim of the cup flares out and its palatine part is covered with wax, there will be no difficulty in removing the impression and model together. If the cup has a flat floor, as it should have in all partial cases, a narrow, thin, but not sharp or curved blade can be passed along this floor on either or both sides, readily detaching the cup. If the surface of the impression has been stained with shellac varnish, there will generally be no great risk of defacing the model. The location of undercuts and spaces and the position of the teeth must be borne in mind, so as to avoid damage to the model as separation progresses.

In separating full undercut cases the rim is first removed by beginning at one corner. Trim away a little of the model to expose the upper border of the impression, which will readily be distinguished by its stain, and, while holding the model against the impression, break away the corner of the latter, and so proceed till all the rim is removed.

In lower undercut cases greater care is necessary in separating than in upper cases of the same kind, on account of the thinness of the model. It will often be necessary in such lower cases to coat the surface of the cup with wax, which causes the impression to adhere, and afterward, when softened, permits the easy removal of the impression and model. If the inside of the cup be rough and wax has not been used, it is well to oil it slightly, as otherwise the impression will adhere with great tenacity; but a film of wax is best for rough as well as

smooth cups. The same precaution must be taken as in upper cases to hold the model against the impression while inserting the knife between the latter and the cup. After the cup has been removed, proceed as in upper cases, first trimming away enough of the model to expose the rim of the impression at one corner, and while holding the two together proceed to break away the rim and remainder of the impression—if necessary piece by piece.

Separating Partial Cases.—It may be laid down as a general rule that it is bad practice to remove the model in any manner which will deface it, merely to save the impression. It is needless to say that one good model is better than three or four defective ones. After rapping the cup lightly, soften the wax and remove the model and impression together. While this removal is being effected be careful that the model is not raised from the impression or the teeth will be broken. In separating, begin as in full cases at one corner, and proceed to chip the plaster from around and between the teeth, removing the palatine part last. Before attempting the removal of this see that all the teeth are entirely free, and then insert the point of a knife-blade at the rear.

A model designed for swaged work should have a hard, polished surface, to protect it from wear and prevent adhesion of the sand. Of all the varnishes used, sandarac is the best for this purpose. But this varnish should not be used for models intended for moulded work, for the reason that it will not stand the high degree of heat required in the vulcanizing process. For moulded work the model is protected either by a mineral varnish or by a thin metallic covering. Of the mineral varnishes, silicate of soda answers the requirements perfectly; and of metallic coverings, thin, tough tin-foil is the best. Silicate of soda should be applied about ten minutes before the flask is closed, as during a longer interval it is liable to crystallize. It is better in most cases not to allow the tin-foil to extend quite to the margin of the plate, which at this part must press closely.

III. Antagonizing and Contour Models.

The model being separated, mark with a pencil around the ridge and across the rear the outline of the plate, which must be free of the facial, palatal, or lingual muscles or folds of mucous membrane. And if it has not been cut in the impression, the shape, size, and position of the vacuum-cavity should be indicated at the same time. In order to prepare the model so as to form a slightly raised edge on the plate, it will be necessary either to have the patient at hand to determine the location and extent of the soft parts or to have carefully noted their position before taking the impression. As before observed, it is necessary in most cases to scrape the heel of the model slightly at and in front of the plate-line, even when the parts have been compressed by the impression; and in cases where the soft parts cover the ridge almost to its border, a shallow groove should be cut around the model close under the plate-line, so as to form a "bead" on the inner margin of the plate.

To avoid repetition and confusion, the general descriptions under this head refer to upper cases. An antagonizing and contour model consists

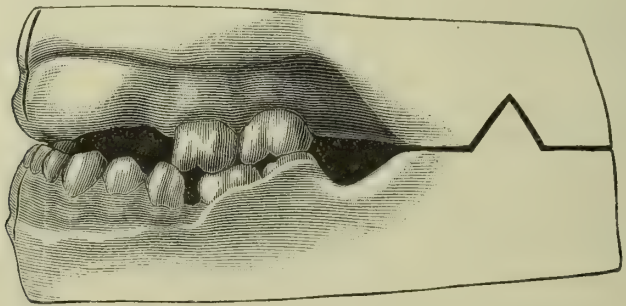
essentially of a semicircle of wax with one surface adapted to the ridge, the other imprinted by the lower teeth, and filling the space previously occupied by the teeth and the tissues which have been absorbed. In partial sets it of course fills only the spaces left by the missing teeth, but in entire sets there are two such semicircles, adapted to the upper and lower ridges respectively, joined at the line of occlusion of the teeth to be supplied. When the teeth have been recently extracted the length and fulness of the lost organs only are represented; but when some weeks or months have elapsed the contour model must fully restore the outline of all the tissues lost by absorption. Besides restoring the contour of the parts and showing the length of the teeth, the occluding surfaces of this model must always be parallel with the lips, so that the teeth when completed will not be higher or lower at one side than the other.

A correct articulation is in importance second only to a perfect impression. What is required in all cases is a natural closure of the jaws. It is not usually possible to close the lower jaw too far back, but there is always a tendency to throw it to one side or project it forward. This tendency results from the effort of the patient to comply with the directions of the operator to close naturally. And it may be observed that the more directions and the greater the *effort* the greater the chances of failure. The methods for securing a correct bite will be given in their proper place. A partial case of one or two teeth seldom requires a contour, and not always an antagonizing model. The latter is necessary in all other cases, and a contour model measuring and bounding the space to be occupied by the artificial teeth and gums is necessary in all large partial cases and in all full sets, single or entire. Yet, on the other hand, no measurements, no matter how exact, can take the place of an observing eye in noting the characteristics and peculiarities of each case, and in partial sets so arranging the teeth as to present a natural appearance and restore the contour. The simplest and shortest method of getting a bite for small partial cases is the following: Take a roll of wax from one to two inches long, according to the number of missing teeth, and about three-fourths of an inch thick; soften and bend into a semicircle; press it against the teeth on each side of the space or spaces requiring substitutes; then direct the patient to bite through the wax until the cutting edges and cusps touch and occlude naturally; then, after pressing the wax against the labial or buccal surfaces of the teeth, carefully remove it from the mouth and harden it in cold water. Before placing it on the model the inner surface may be slightly softened, to avoid breaking the plaster teeth. This bite must be adjusted to the model with the nicest accuracy. After this has been done fill the palate of the model with some wet paper; oil or soap the ends of the plaster teeth on the model; mix plaster quite thin; first fill the imprints of the teeth in the wax, and as the plaster stiffens build up and extend it over the tops of the plaster teeth upon the model, oiled as just directed, and across the palate, upon the surface of wet paper, until about three-fourths of an inch thick. When the plaster is hard, soften the wax, remove the model, and carefully separate the wax, which should be quite soft, from the plaster "bite."

If proper care has been taken, we now have the jaws, teeth, and their cusps precisely in their normal relations; nor could the most elaborate articulator retain the teeth more accurately in their proper positions. When the base-plate is adjusted to the model the case is ready for the teeth. This method applies equally well to swaged or moulded work. Of course it will be readily seen that in swaged work the metal plate always, when obtaining a bite, takes the place of the wax base-plate in moulded work.

When partial sets of four teeth or more are to be inserted, the following method may be adopted: Place on the model a paraffin and wax or a gutta-percha base-plate; adjust pieces of softened wax in the spaces that are to be supplied with teeth; put the plate with the wax attached in the mouth and direct the patient to bring the teeth lightly against its lower surface. If this is seen to be correctly done, let the patient close the teeth firmly together. The wax can now be removed, and modified so as to indicate the length and fulness of the teeth. When trimmed to the proper shape, place again in the mouth, and, after carefully noting that all is correct, mark the median line, taking the middle of the lips as a guide. When it is considered necessary to secure a full model of the teeth in the lower jaw, one or the other of two methods can be followed. Either add enough wax to the rim for the upper bite to imbed the full length of the lower teeth, and obtain a model as already described, or, what is better in at least large partial cases, take a full wax impression of the lower teeth and run into this a plaster model. The wax impression of the lower teeth should be as accurate as possible, in order to show all their characteristics as well as the spaces between, to the end that the artificial teeth may be arranged to resemble the natural teeth as much as it is desirable. Of course the edges and cusps of the teeth on this model will exactly fit into the prints of the lower teeth left in the upper wax. If there are three or four points of contact not too near each other, the models can be used as they are in fitting up the teeth; but when the occlusion is not definite or the points of contact are too few, it will be necessary to secure additional bearing, which is

Fig. 315.



Primitive Plaster Articulator. The V-shaped line shows the deep groove in the "added part" or extension of the model. In this cut the wax contour model is not shown.

obtained by extending both models back about two inches. First lay the model on the table with the face up; pass around it and the part

to be added a strip of wax, sheet lead, or stiff paper about an inch and a half wide; fill the space thus enclosed back of the model with plaster, being careful to keep it off the face of the model. When hard, trim and shape the added part, and cut one or two rather large and deep transverse grooves across the under side; oil the surface of the new part, including the grooves; place the model on the table as before; put the base-plate with the contour model accurately in position; adjust the articulating model; close the opening between the two with wet paper; surround the whole with the wax or paper ring; and with plaster not too thin fill the space thus formed back of the articulating model and add a little to its thickness (Fig. 315). All surfaces of this plaster articulator, except the face of the upper model, are coated with sandarac varnish to protect the hands from contact with the plaster. It is well to varnish all articulators in the same way.

When the case is a full upper or lower one, or a large partial without antagonizing teeth, securing a correct articulation often becomes not a little difficult and uncertain. As already remarked, there is sometimes a tendency to throw the jaw to one side, and nearly always to project it forward. This is often the result of too many and too confusing directions on the part of the operator, but is generally the natural consequence of too much effort on the part of the patient. If, instead of being told to close the teeth naturally, the patient is directed to close them *easily* or *lightly*, better results are usually attained.

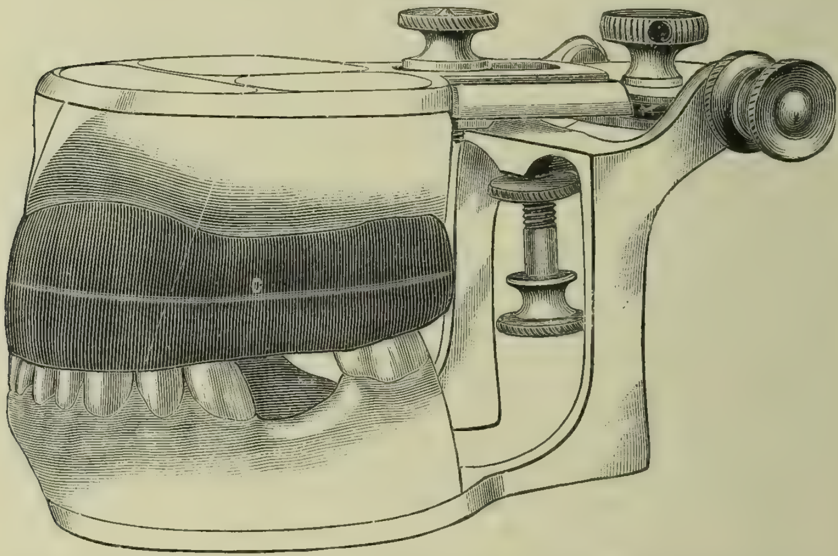
In full upper or lower or in large partial cases for either jaw, first fit the base-plate accurately on the model—so accurately that when placed in the mouth all plates for upper cases will be retained by atmospheric pressure. Observe the same accuracy in lower cases; and besides, in order to prevent the plate bending in putting it in and taking it from the mouth, imbed in it a semicircle of iron wire, about No. 15 standard gauge. Attach to the base-plate a rim of yellow wax which shall represent a little more than the length and fulness of the teeth to be replaced; put the plate with the rim united to it in the mouth; mark the points where the wax is too full or long; remove and trim, and, if necessary, repeat this process until the proper length, fulness, and contour are attained. The upper incisors are generally about a line longer, and the lower incisors a line shorter, than the upper and lower lips respectively. As a general rule, the upper cuspids are of the same length as the lip. In some rare cases the lower teeth are more exposed than the upper, and in other cases the lower teeth have become so elongated that upper artificial teeth cannot be made to show at all. In not a few cases the whole length of the upper front teeth is exposed to view. From these facts it is evident that no set rules or measurements, however exact, can be taken as guides, and that the various forms and expressions of features must be carefully studied, and the artificial denture be made to conform to the natural requirements of each case.

When the semicircle of wax has been trimmed to represent the required length and fulness, and its lower border is parallel with the lip, soften the under surface slightly, and when in position request the patient to close lightly against it a number of times, carefully noting the points of contact, to be certain that they are the same each time.

If the patient has closed with little effort, and there is no variation in the tooth-marks on the wax, the bite is doubtless correct. The teeth should now be pressed into the wax to imbed the cusps and cutting edges. The depth to which the cutting edges shall be imbedded must equal the "overbite" of the upper teeth. If this rule be followed the teeth will always have their proper length.

When this result has been secured, mark the median line on the wax rim, and afterward extend it up across the front of the model. A wax impression of the lower teeth is now taken and a plaster model run, which must be accurately set in the prints made by the lower teeth in the upper wax (Fig. 316). In some cases the patient will persist in

Fig. 316.



Showing the contour model in position. It consists of pink wax and paraffin, which forms the base-plate, and is marked C in the cut, and of yellow wax, which is below the horizontal line under C, and which represents the *length*, *fulness*, and *position* of the teeth with respect to the lips.

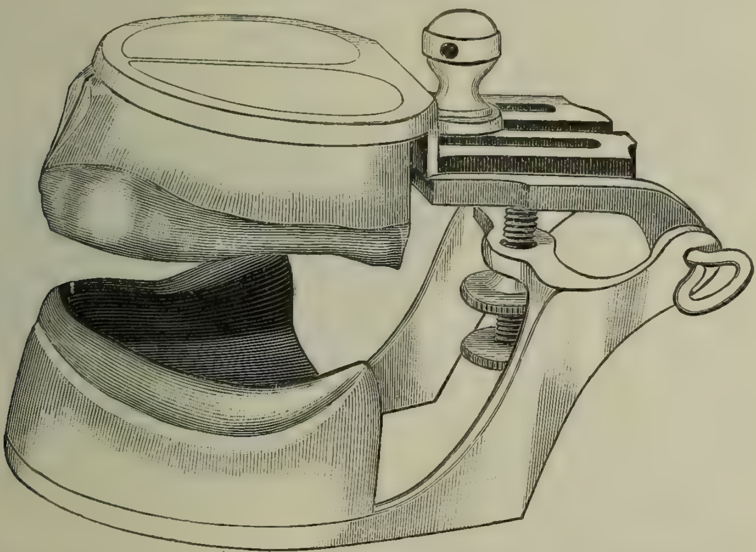
holding the jaw so rigidly that all directions and efforts will be useless. It will then be necessary to resort to other methods. Perhaps the best that can be adopted is to request the patient to swallow and close the teeth at the same time. By this means the patient's attention is given chiefly to the act of swallowing, and the teeth are closed without any special effort. It is also a very good plan to have the patient sit upright and throw the head as far back as possible, and then close the jaws lightly or without special effort several times. This position stretches the throat-muscles, so that it is not usually possible to throw the jaw forward. Before the contour model is removed a line should be drawn with a pen or pencil *across the lower front teeth* at the lower border of the yellow wax. This mark will show the length of the "overbite" of the upper teeth.

To secure articulation for entire sets, mark the plate-lines; place a base-plate on each model, imbedding in the lower one a semicircle of

iron wire; make wax rims, which should be about one-fourth of an inch thick, and in height equal to the length of the teeth. Place the plate with the wax rims attached in the mouth, the lower first; note any excess or deficiency in length or fulness, and cut away or add wax until the natural contour is restored and the occluding borders of the rims when brought together touch at the same instant all around without tilting from the ridge, and are parallel with the lips. If the upper plate represents the exact length of the teeth, the lower rim must be shorter to make allowance for the "underbite." But if the "overbite" is very short, or the upper and lower front teeth meet edge to edge, each rim should represent the precise length of the upper and lower teeth respectively. In all cases the line of union between the semicircles of wax must not only be parallel with the lips, but must represent the length of the teeth to be introduced.

As already stated, the upper teeth are about a line longer than the upper lip, and the lower a line shorter than the lower lip. The front teeth will be exposed to view more or less according to the real or apparent length of the upper lip. The exact degree of fulness will be determined by the age of the patient. An aged patient who had been

FIG. 317.



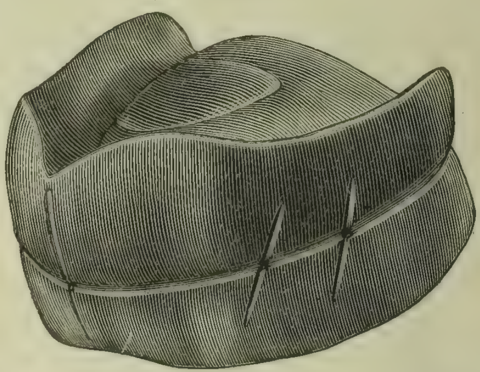
Represents the plaster models mounted for an entire denture. The contour model (Fig. 318) has been removed.

without teeth for some years would not require or admit of such a restoration of contour as would be required in a young person. In many cases the deformity caused by a protruding jaw or very thick alveolar process can be corrected to a greater or less extent according to the cast of features or fulness of the lips and degree of absorption of the osseous tissues. In cases where the natural teeth were abnormal the defect should not be reproduced in their substitutes.

After the proper facial contour has been secured by the rim, and the jaws closed naturally, so as to bring them into their proper relation, the one with the other, the median line marked in the wax, the rims must be so united that they can be drawn from the mouth together. This can be accomplished by either of the following methods: First, by softening the occluding surfaces, causing them to adhere by contact, and then drawing one or two vertical or oblique lines across their buccal or labial surfaces, so that if separated by accident they can be accurately united, or the rims may be kept together by pressing small wire staples into them; second, by softening the surface of the upper rim only, and placing on the lower four or five little cones of wax, or fixing into it three or four artificial teeth, which, when pressed into the upper rim, will securely unite the two and will act as guide-pins in case of separation. It is always desirable to unite the rims so securely that they can easily be taken from the mouth together.

An articulator can now be made either by the models in these plates or by running into them temporary models, and extending these back about two inches in the manner already described for upper or lower cases; or the models, after being set in their respective plates, may be put in an articulating frame or articulator (Fig. 317), of which there are many forms. The articulator shown in Fig. 317 (one of the S. S. White patterns) is an excellent one, and can be adapted to single or entire sets by inverting the upper jaw. The more nearly these conform to the size, shape, relative position, and movements of the natural jaws, the more certain, other things being equal, is the operator to secure a correct articulation. All the parts of an articulator should be so rigid that they will not bend or spring, and they must be adjusted with the nicest accuracy. Besides the opening and closing movements, an articulator—or, to be more exact, its upper jaw—moves laterally and slides backward and forward, the latter movement being the most useful. It is an advantage to have these movements separate, as in the Codman and Shurtleff articulator (Fig. 316), which, besides, is so jointed or hinged that the wear can be readily taken up—a point of the utmost importance in securing a perfect occlusion. Some articulators are made of metal so soft and with bearings so small that they soon wear loose and become worthless. Much of the grinding and filing required when fitting in teeth is due to this cause alone. The screw which regulates the space between the jaws should have a set-nut to fix them at the proper point.

Fig. 318.



Wax Contour Models for Fig. 317. On these may be seen the median line and the marks designed to show the correct adjustment of the parts in case of accidental separations.

All the screws and nuts should be kept so tight at all times as to be secure against the possibility of movement.

The parts of an articulator should, when necessary, be moved and securely fixed, not after, but before, the models are adjusted and fastened. If in taking the bite the jaws are closed naturally, there is no occasion for slides and screws to readjust the relative positions of the models; and if the bite be taken incorrectly, no number of slides or screws, or even ball-and-socket joints, can make it correct, except by the merest chance.

What is essentially required is an exact model of each jaw in its natural relations to the other. In partial cases with close occlusion of the remaining molars and bicuspids, nothing is really required but the models accurately articulated; but even in such cases an articulating frame is at least a great convenience, since it becomes a holder for the models. It is only when the points of contact are too few or too close together that additional bearing becomes a necessity; and when the teeth in one or both jaws are all to be replaced, a metallic articulator answers the purpose better than anything else. The wax bite simply holds the jaws in their proper relations until additional bearing is obtained by extending the models backward or until they are fastened in a frame, which, as before observed, should resemble the size, shape, and movements of the jaws. The primitive plaster articulator (Fig. 315) answers a good purpose as an illustration, and does well enough in many partial cases, but its defects and limitations appear at once when for any reason it becomes necessary to increase or diminish the space between the models. It is almost if not quite impossible to determine with the bite the exact length of the teeth in every case; hence any articulator for upper or lower or entire sets or partial sets requiring the bite to be opened must at least allow the models to be separated or brought together without disturbing their relative positions.

THE GEOMETRICAL AND MECHANICAL LAWS OF THE ARTICULATION OF THE HUMAN TEETH.—THE ANATOMICAL ARTICULATOR.

By W. G. A. BONWILL, D. D. S.

After more than thirty years of active life in dentistry I am fully persuaded that of all that constitutes dentistry proper the mechanical forms the basis. And yet to make anything that is beautiful in our art, especially in vieing with nature in matching the teeth, we must be more than mere mechanics, more than capable of filling a tooth or treating an abscess; we must be dental artists. When we introduce a set of teeth upon which depends so largely the expression of the face from the soul beneath, we must bring to our aid not only the laws of mechanics and geometry, but the beauties of art. It is not enough that we accurately adapt the plate to the gums; that we so grind the teeth to the plate as to be water-tight; that we so make every joint that it cannot be distinguished; that we so polish the plate over symmetrical curves that the tongue cannot find the least fault. We must do something besides this: we must impart *action* to these otherwise whited sepulchres; we must instil life therein or our labor will be in vain. A tooth may be elegantly shaped and colored, yet if it lacks the proper shape for the person for whom it is intended and is unskilfully set in the arch, it is a failure. The blocks from the same mould set by different operators may vary in effect in every case. For this the operator should have a number of blocks of the various shapes, colors, and sizes, and try them under the lips until his judgment tells him which to use. The dentist's taste can be so cultivated that he will be apt to criticise his own selections.

I shall use the term "articulation," instead of "occlusion," for the very good reason that it is more in keeping with the functions or the motions of the jaw. If there was but one movement to the lower jaw, and that up and down, we might possibly say occlusion. But this latter term applies more properly to the shutting the lips or closing the mouth, and not to the motion of the lower jaw dependent on the articulation of the same at the glenoid cavity, where the articulation is universal. Articulation is a word of action throughout, while occlusion answers to the mere act of closing the teeth and lips and keeping them closed; one is active, the other passive. Before we can comprehend, then, what constitutes true articulation of artificial teeth, we must look at the anatomy of the human jaw and its functions.

We find from twenty-eight to thirty-two teeth in each jaw, arranged in such manner that no two strike directly against each other, but antagonizing in such a manner as to prevent the whole denture from becoming very irregular, which would be the case if striking one against another. By this arrangement, when one tooth is lost the regularity of the arch is interfered with. As necessary as this is in nature, it is not positively necessary to follow it in artificial work, although for the sake of harmony it should be done.

It will be found in 95 per cent. of cases that the upper teeth project over the lower, and that the depth of overbite varies as the depth of the cusps of the bicuspids are deep or shallow; the ramus will be found to come upward and backward in relative proportion to the length of the cusps and the overbite.

One point of very great importance has not been given in general or special anatomy: *the peculiar tripod arrangement of the lower jaw, forming an equilateral triangle.*

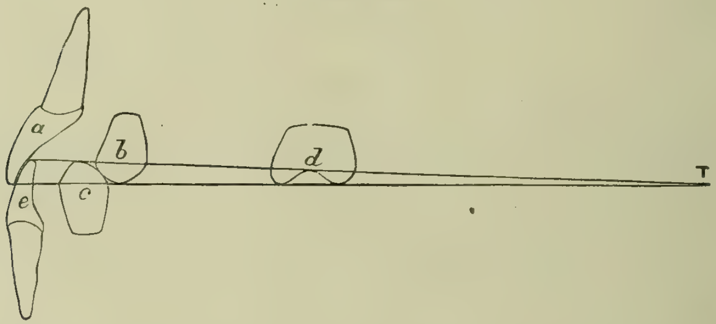
From the centre of one condyloid process to the other four inches is about the average; and it will be found that from this same centre of the condyloid process to the median line at the point where the inferior centrals touch at the cutting edge is also four inches. It is strange that it should have been overlooked; but it only shows, when studied in a geometrical and mechanical sense, the great wisdom in our formation. It varies, but never more than about one-half of an inch, which would make no difference in describing the arc of a circle. No matter what the width from the processes, the distance is the same to the median line of the lower jaw. Were the lines of the angle five feet, the teeth made in the anatomical articulator would fit the case. It will be perceived that in setting artificial teeth, one-fourth of an inch, the radius of the circle, would not materially alter the articulation. Without such an arrangement the teeth would have to be flat on their grinding surfaces to admit of lateral movement. Besides, there would not be the beautiful and wise curvature at the ramus for equalizing the force applied to the teeth in all directions.

Imagine the human jaw jointed in a line with the pharynx, or as is seen in the ordinary brass articulators. Can it be supposed that there would be any greater wisdom displayed in such hinging or articulating a part destined to such varying motions and powerful wrenching force? No! The study of this one part of the head and jaws shows one of the most striking designs of an Architect; and when studied it will be seen that every part of our frame is made by a positive law and to subserve definite purposes, such a law being in consonance with geometry, physics, and mechanics. We must see the true use or function of the jaw and the teeth and the food destined for us, and how it should be comminuted; there is no chance work about it! Law and order pervade every part. The jaw forms a perfect triangle, for the purpose of bringing into contact the largest amount of grinding surface of the bicuspids and molars, and at the same time to have the incisors on one side at once come into action during these lateral movements.

It will also be found that from the cuspids, the bicuspids and molars run in nearly a straight line, instead of a curved one, back toward the

condyloid process, enabling them to keep the largest amount of surface always presented for mastication. Another thing which has never been explained by anatomists or naturalists is the law of the normal relation of the upper to the lower incisors. The normal jaw should overjet, and also have a corresponding underbite. Without such a law the incisors would lose largely their functions, that of incising on the principle of a pair of scissors. Where the incisors strike directly upon each other the power to cut off food would be very much lessened. The length of cusps on the bicuspids and molars proves the law.

Fig. 319.



Another unobserved fact: where law is supreme, where there is an overbite and underbite, just in proportion to their depth will be the length of the cusps of the cuspids, bicuspids, and molars.

By drawing two lines from T to F, Fig. 326, or T to *a* and *e*, Fig. 319, we have the lengths of the cusps of the bicuspids, *b*, in the upper and *c* in the lower, and also *d*, the second upper molar. The depth of the underbite is one-eighth of an inch from the cutting edge of the inferior central incisor *e* to that of the superior central incisor *a*. Did the teeth extend as far back as A, A, there would be flat surfaces at those points. But in articulating artificial teeth, when the superior second molar is reached its distal cusp has to be raised from line T *e* to T *a* (Fig. 319), to allow the

Fig. 320.

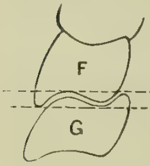


Fig. 321.

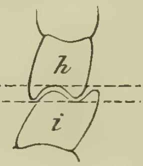
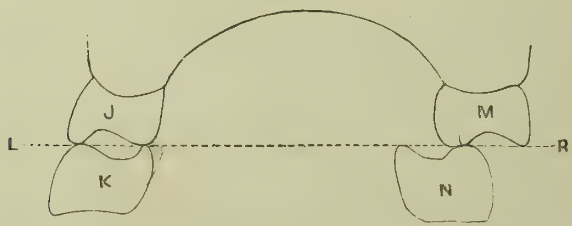


Fig. 322.



molar teeth on the opposite side, not in mastication, to touch, for

merely balancing the plate, as Fig. 322, M, N, otherwise the second molars would be of no use in lateral movement, nor would the first molars. This curvature at the ramus (see Figs. 323 and 324) commences at the first molar, although it shows itself slightly in the bicuspids. Practically, it need commence at the first upper molar. This curve, then, will always be proportioned by the underbite at *a*, *e*. The length of the cusps on bicuspids will never be more than an eighth of an inch, normally; the groove deeper than that would cut the palatal cusp off, and make of it a cuspid. It would in reality be cut in twain. *This is another unobserved fact. It always has been and will be found in the archtype of human jaws.*

Fig. 323.

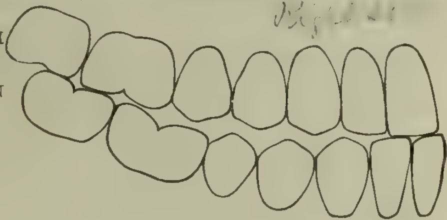
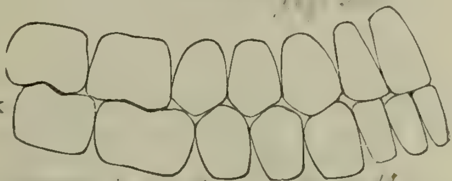


Fig. 324.



So that when a first superior bicuspid is seen it can very well be told from the length of the cusps whether the jaw from which it came had a depth of underbite of one-sixteenth of an inch or more. Where the teeth all strike fairly one upon the other, without overbite, then there is no occasion for cusps. If originally there, they would soon be worn off from the abnormal articulation.

This provision of articulation is most wise, carrying out still more fully the exact law by which the anatomical movements of the lower jaw for perfect mastication are governed. So beautiful and so mathematical a design cannot but call forth our admiration and wonder, and the study of no other part of the human body will give one a clearer idea of infinite wisdom. This movement, we will find in the artificial sets arranged upon this law, will prevent the plates from tilting. In the natural denture the incisors are really the first teeth to be arranged, though the first molars emerge first to assist in the more perfect mastication of food and to keep the jaws at the proper distance. The incisors show a definite fixedness of purpose to arrange themselves after their typal shape, and to form the overjet and overbite at a given depth for the accommodation of the bicuspids and molars, which are soon to appear, having cusps of a definite length, so that the law of articulation which has been premeditated to a certain typal shape and construction be carried out.

It will also be found that the grinding surfaces of the bicuspids and molars have a typal shape, allowing them to meet with all their surfaces touching, for an express purpose, after a preordained and established law, from which the greatest area is gained for mastication, and that the inner cusps of the lower teeth are as necessary as the outer of the superior when laterally moved. The law is still farther carried out

in the curvature at the ramus from the second bicuspid to the third molar, to permit of all the surfaces on one side to be in contact (Fig. 324), while the other unused side is only partially so. (See Fig. 323.) The nearly straight line of arrangement from the cuspids to the last molar is also in keeping with the underbite (Fig. 319). It may well be asked, just here, "Will this law hold good in an artificial articulator such as I use, applied to the setting of artificial teeth?" As soon as the attempt to apply this principle is once made the operator must certainly grasp this law, so wise and beautiful. There may be variations, but the general law will hold good, and where there has been much latitude or varying from it by abnormal mixtures of races or types, if Nature is given a fair chance to right herself she will return to the normal standard of mathematical and mechanical precision: to do otherwise would annihilate creation. *Cells free to arrange themselves must develop the original creation, and perpetuate and keep it to the perfect standard, by selecting the highest type of perfection in shape, strength, beauty, etc.*

Could the reader but stand beside me while I arrange a set of teeth in this articulator, he would of necessity become converted to my system as founded on law and not on chance. There is no other part of the human body that will permit of thus handling and unfolding, and again rearranging—no other that stands outside its own organic workings that will permit such demonstration. It is the key to the revelation of Nature's inner workings, and unfolds, without a *missing link*, what we were, absolutely perfect in cell and organism from the inception, and simply in conformity to an infinite and all-wise law which cannot be blotted out. The teeth, individually, have been a great factor in science; and when they can be looked at from the point of view herein laid down and hitherto undeveloped, their significance will be magnified; and if we, as dentists, but take up the work as only belonging to our specialty, and scientifically prosecute it, our honors and standing will be enhanced.

Upon these bases I shall found the science of articulation, and apply it to the arrangement of all artificial substitutes, changing to suit individual peculiarities. The query here naturally arises, to those who have never looked into the philosophy of this matter, whether these peculiarities are necessary, and if it is possible to utilize them in our artificial dentures; and if so, how can it be done by any of the articulators now in the market, or can it be done at all by any human device? To all these inquiries I answer in the affirmative.

As to the necessity, it should need no argument to convince the reader that an artificial denture should correspond to the natural one in every respect as nearly as can be approached. It may be a question how nearly art and mechanics can imitate the natural movements and expressions. Has there ever been any rule heretofore given by which can be regulated the beginning and ending with any kind of design? Is there any chart, system, or plan to go upon, such as the plot or sketches by which an architect, artist, or sculptor can bring forth his ideal? No! I say most emphatically. Look at all the sets of teeth made, I care not from whose hands they come, and there will not be found one made after any special law to suit the individual case. Not that no sets have ever

been made that have been serviceable or looked well, or in which taste has been manifested—I have seen many; but how much more useful and life-like they can be made by following the system as found in the natural jaw! I have remarked that it is so strange that these points should have been so long overlooked. To have examined the human jaw critically should have led to the plan at once. But we have acted on the principle that artificial teeth can only admit of the up-and-down or hinge-like movement. To allow of the lateral motion is thought to be impracticable, as it would throw or upset them and render them difficult to keep in place. The regular horseshoe shape has been adhered to up to the present, for fear that if the molars were placed outside the arch the plate would tilt and mastication be impossible. To give to the teeth the greatest advantage, it is taught by some to let the cutting edges of the incisors meet squarely and have no overbite. If there has to be an overbite, then the arch must be so large and wide that it is more than normal.

It is taught that it is vandalism to grind the antagonizing surfaces of teeth, as if there was but one magnate to see them, the manufacturer of them. It is also taught that but one side or cusp of the bicuspids and molars can be made to antagonize. As I have studied the matter in its manifold bearings, and as my forte is in mechanics, I speak as having authority; and if practice is of any value in establishing theory, I am prepared to give it in various ways, and attest that the adaptation of such work in the mouth holds good to the law, as it does in the articulator I am about to describe. So that when there has been fitted in this device, on the law laid down here, a set of teeth for any jaw, it can be relied upon that if the jaw itself was in the operator's hands he could not approach more nearly to what is demanded. In some cases there is need of touching a cusp here and there, but to a very trifling amount.

This triangle can only be found within a perfect circle in which there are the greatest breadth and area of surface. No other geometrical angle would have given such perfect beauty and symmetry to the face. The compactness brings the largest number of teeth nearest the centre of motion. The double joint permits the greatest strength and the easiest lateral movement, with the greatest range of this at the least expense of power and compass. It permits the largest number of teeth to antagonize at every movement; *and, not least of all, this very triangle is the means by which Nature develops the typal shape of the ramus and of the formation of the jaws, the underbite, etc.*

It will be observed that in making the lateral movement of the lower jaw to the left the condyle of the left side stands still or does not move backward; it merely revolves or rotates in its socket, which is but a trifle. The right condyle moves forward in the glenoid cavity fully half an inch when at its farthest limit, causing the outer cusps of the upper, from the centrals to the last molar, to touch the outer and inner or buccal and lingual cusps of the lower on same side, the left (Fig. 324, and J, K, Fig. 322); and on the opposite side (Fig. 323, and M, N, Fig. 322)—the right—we find only the inner cusps of the bicuspids and molars of the upper to come in contact with the outer of the

lower, and the centrals to the cuspids do not touch. And why so little surface touching on right side when the lower jaw is thrown to the left? A person cannot masticate on more than one side at once, and when the jaw is thrown to the left in the act of masticating (see Figs. 322 and 324) the food is upon that side; hence there is no necessity for the right side to have so much surface in contact. But why should it touch at all on the right? In order that the muscles of both sides should act equally, which could not be done if the teeth were not allowed to strike there, giving support to that side of the jaw and equalizing the force brought to bear upon that side, although no food be there. If there were no touching of the teeth on that side while mastication is going on upon the left side, there would result, as a sequence, that peculiar movement of the lower jaw at the condyloid process which makes it difficult to insert teeth for the aged or those even in early life who have lost all the grinders on one side.

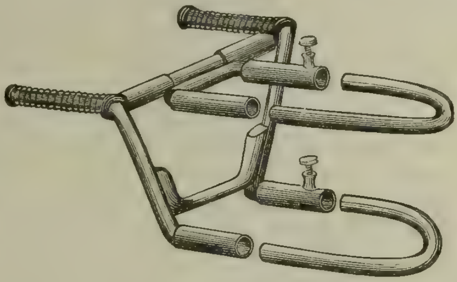
This form of triangle is necessary, again, for the purpose of giving the largest number of muscles a chance to act on both sides simultaneously and concentratedly, thereby keeping the circle or arch of grinders down to their work and equalizing the pressure on all sides. It enables the teeth on the side where the chewing is being done to arrange themselves when erupting so that they will be very nearly in a line with the left condyle, which is now passive on this side, and forms one point of the dividers in forming the arc of a circle; and by this condyle being where it is—four inches from the other—the molars and bicuspids, as well as the central of that side, all come into the most perfect contact for chewing and incising, thereby carrying out this absolute law of Nature of the perfect adaptation of geometry and mechanics to her uses, and having no lost motion or function in any part.

Again, the triangle gives an extra motion forward, which brings the lower teeth in contact with the upper to incise or cut off food presented there. The type has been preordained, just as has the nose or the peculiar shape of the eye or any other one part of the body. If in the arrangement of the teeth in the human jaw no type or design were laid down in conception or embryonic life, what malformed creatures we should be mentally and physically! *And it will be found that just in proportion as there is congenital insanity or want of will or directing power, there will be a malformation in the arrangement of the teeth, while in shape they are perfect.*

The next step, now that we know the exact shape of the jaw and its philosophy of form and functions, is to have at our command something so nearly approaching it that we can place our models upon it, and thus again restore Nature's "lost art." I believe that in the anatomical articulator I have it so nearly that it will be found to answer our most fastidious notions of setting by a system teeth on plate. The instrument (Fig. 325) is made of brass wire one-eighth of an inch in diameter, and of such shape and movements as to correspond exactly with the mechanism of the human jaws. The base with its movements forms one part, and the two bows another. But one base is necessary for any number of cases. The bows, which here are separated from the base, can be duplicated to any extent. They are held firmly by thumb-screws, and

after a case is once articulated to the bows they can be laid aside for future use. The lateral motion forbids the use of a prop to keep the bows apart. At first sight it would seem that the lower bow is moving in the wrong direction. Its motions are precise and correct. This has never been changed in design since first invented in 1858. It permits of seeing whether the palatal and lingual cusps properly touch. In using it to get lateral movement, one condyle must be kept close to the point where it is held by the spiral spring, while the opposite one moves forward. Never use both springs at once, except in bringing the lower jaw forward for incising. This method demonstrates there is but one way to make a set of teeth articulate.

FIG. 325.



Before placing the wax models in the articulator it will not be out of place to say a word about the arrangement of the wax on the base-plate and the selection of teeth in full sets. Always model the upper wax first, judging of the length of incisors by the trial of an artificial tooth in the mouth, such in shape, length, and width as would look natural and appropriate when held under the lip. This will enable the operator to get the height of wax and the contour after successive trials. The modelling of the wax on the upper plate is arbitrary and fixed. Here the true dental artist comes in. The length is obtained by trial of several blocks or single gum or plain teeth, as may be, as well as the shade of the same. As to the arch of the upper jaw, the operator must add to and take from, making depressions, etc., until his judgment tells him that it is correct. To aid amazingly in this work of art draw out the patient in a smile or broad convulsive laugh: compel laughter. Nothing tends so to relax most universally every muscle and give true expression to the countenance. If the wax is not in keeping with symmetry, where the trouble lies will be seen. Look at him in front and on either side when he is laughing as a sculptor would upon his model. Be sure that the cuspids that form a double keystone to the arch stand out more prominently than any others. The superior first bicuspid should nearly always fall back somewhat behind the cuspids.

Now that the upper wax is correct, the same rule applies to the lower. It is easy to make this conform to the upper; the upper in some respects when tried with the lower may have to be changed, but not much. The length of wax at the molars may have to be trimmed to allow of equalizing the length of the teeth on upper and lower plates. Laughing and smiling will here again tell. Be sure to mark the centre at the median line, making marks or grooves through on either side, running from upper to lower for guide; they can be removed, and are then ready for the articulator, with the bows pushed into their sockets in the base, which are retained by set-screws. The plaster models or casts with the wax articulation or bite thereon, being fastened together by wax or

cement to prevent their being displaced from each other, are then placed on this lower bow of the articulator, and the upper bow is brought over upon the upper cast. The eye soon detects whether the median line or wax is in the centre. To get the cast in proper place have a pair of dividers four inches between points, and by it place the cast in position, with the centre of the lower teeth just four inches from the condyles on either side. Hold in position while with plaster the upper is secured to the bow, and when hard the lower bow to the plaster cast in the same way.

It may be asked, Where is the set-screw to hold open the jaws of the articulator after the wax is taken off? I have never found it necessary in this kind of frame. Before taking off the wax I take a pair of dividers, or a piece of wire bent with the points about one inch and a half apart, and with one foot on the plaster cast and the other at the cutting edge of the wax mark the bite at the median line on the plaster cast. This is done for both jaws. To secure this height for future use, mark on each cast with the dividers the distance apart or the width of the dividers, and this will always be a guide for height. Take off all the upper wax, except a section at the molars, first, and let the lower remain as a guide for the arch of the upper. The first block or tooth fitted on the upper when backed with wax answers perfectly to keep the jaws of the articulator apart. The set-screw would be in the way with the lateral movements. The length or depth of underbite in full sets is restricted to the width of the jaws and length of the centrals, which it is presumed have been selected to suit the individual case. Knowing how much the underbite is to be, it can very nearly be guessed how much to cut out the bicuspids and molars on all the grinding surfaces *before any of them are fastened to the base-plate*, and how much arch upward at the ramus from the second bicuspid backward and upward. If the underbite at the centrals is to be an eighth of an inch, then the biscuspids in the upper will have grooves between the cusps not quite so deep, and the molars still less. From the cuspids, then, the cusps are less to the second molar: were the incisors to strike equally and directly on each other, there could be no cusps or they would be of no use. The inner cusps of the upper should, as a general rule, be longer or higher than the outer. (See Figs. 320 and 322.) The outer cusp is more acute, the inner rounded. The lower the reverse—the inner sharper and the outer rounded where the upper closes over the lower. For full sets but slight underbite is needed—only enough to permit the lower to come forward and act as shears for cutting; at the same time it permits of cusps to both bicuspids and molars, and gives all a double amount of grinding surface: the cusps touch on the palatal and lingual sides at the same time as the buccal.

If for an upper set alone, the overbite of the upper incisors can be told by looking at the curvature of lower molar teeth remaining. If an eighth of an inch out of line, the overbite should be fully so. This, when once understood, can give no trouble. The grooves in bicuspids and molars will form with the cusps, buccal and lingual, an ogee, as seen in Figs. 320 and 322, to give double the grinding surface when worked laterally, besides giving double cutting

edges. All these grooves can be cut out before any are fastened with wax, so nearly that but little touching will be needed when the lower is articulated to the upper. *The first bicuspid in the lower jaw should have but one cusp.* This perfect design will be seen in the articulator why it should have but one. Two would not only be in the way of the tongue, but be of no use. Be sure that the groove in the upper is made nearer the buccal side and for the lower on lingual side, for a reason which will presently be explained, as seen in Fig. 320. Now that the grooves are completed in the upper and all the teeth in place in the arch, we will articulate the teeth on the lower base. The height is soon ascertained by the dividers, and the central incisors tried on to see what changes will be needed. Fasten temporarily with wax, and try with the lateral motion and the points adjusted to meet all the surface on the palatal side of upper teeth when the lower is thrown to the side of the tooth being fitted. Cut from the cutting surfaces of each whatever will make the most natural and strongest case. If for a very young subject be careful, but for a middle-aged or elderly person do not scruple about the cutting edge and grinding surfaces, but sacrifice even the labial or palatal surface for the sake of effect and usefulness.

I sometimes turn the buccal side of a molar inward to save substance and get effect, and for better adjustment; frequently for want of room at the ramus I do this; and, occasionally turn the buccal side upward for the grinding surface. If using blocks, before the front ones are fastened securely to the base-plate, and while they are temporarily in their right place, try the bicuspid blocks, to find out how much of the joint should come off of the incisors or the bicuspid block; or divide it. This will secure a better and more continuous joint, and give the lower a better chance to be arranged to the upper. Before taking off too much of the joint of either of these blocks, try the lower incisor and bicuspid blocks temporarily on the wax, to know where the cusps are going to come. Regulate the joints by this. The groove in the lower blocks can be made the reverse of the upper, and they can all be cut out before much jointing is done, taking care that the groove is in this case on the lingual side and that the buccal cusps are rounded, and the inner more acute, as in the buccal of the upper. *Never cut off any of the lingual cusps of the lower biscuspid and molar of artificial teeth*, such as are now made, as they are universally too short. To get them long enough for service a large portion of the buccal cusps have to be cut down and rounded.

The palatal cusps of the upper strike between the outer and inner cusps of the lower (see Fig. 320), and at the same time these cusps should be long enough to allow in the lateral movement the incisors and cuspid on that same side to touch simultaneously all the surface from the central to the last molar. If they do not, then the remedy is to make the groove deeper in both upper and lower, or perhaps the lower only or the upper only. (See J, K, Fig. 322.) Experience here will soon teach which. When all the cusps are touching inner and outer and the front one, take the opposite bicuspid and do likewise; and with the additional precaution, when the lower jaw of the articulator is turned to the left, to make the inner cusps of the upper strike the outer cusps of

the lower (M, N, Fig. 322), and *vice versâ* when thrown to the lateral right or left (J, K, Fig. 322). The molars must have the same rule applied, with yet another additional point of great importance—namely,

The curvature of the ramus must be made to conform to the depth of the overbite (see Figs. 323 and 324), so that when the lower jaw is thrown to the left, the outer and inner cusps of both upper and lower sets on that side come together at the same time that the bicuspids and incisors do (see Fig. 324); but the curvature should be great enough to permit, on the opposite side, of the second molar tooth in the lower, which slides forward to meet the first molar in the upper, apparently moving backward (Fig. 323). If they were on a plane, they would never touch, on account of the jaws opening as they move laterally to the right or left to mount up on the cusps of the incisors an eighth of an inch, which would not allow the molars to touch if on a straight line backward. But inasmuch as on the plane of the grinding surface the first upper molar stands higher in the upper plane, the sliding forward of the lower jaw in the glenoid cavity brings the higher second molar in the lower in continuous contact with the first superior molar, as well as both outer and inner cusps of bicuspids and molars of the upper and lower jaw. (See Fig. 323.) This is specially done to equalize the pressure and force on both sides or parts of the dental arches. This permits of the most compensating arrangement of the teeth for equalizing the action of muscles on both sides simultaneously, and getting the greatest amount of grinding surface at each movement. This arrangement of bicuspids and molars is found in nearly all the lower animals: *the incisors, however, never touch when the jaws are in lateral movement.* Turn the lower jaw to either side, and the effect is the same. *As I before said, but one side of the mouth can be used at the same instant, leaving the other free to balance the other side at work.*

If the upper arch of the incisors *of the natural teeth* should be broad or deep on account of the thickness of the base or body of the incisors, or where they are much inclined to protrude, then the arch at the ramus is not so great. In artificial sets this need ever occur, carrying out the same rule in nearly every case of continuing the curvature at the ramus by the depth of the overbite and length of cusps of bicuspids. This system holds good in partial sets as well.

This is all that is necessary to be said on articulation proper: it remains only to give a few points having a bearing on the perfection of the same. Select the broadest grinding surfaces to bicuspids and molars, that the bolus of food may be held securely on their faces, taxing less the muscles of the face engaged in mastication. Narrow surface would rather tend to cut the food than grind it. This is of no mean importance in rendering artificial teeth of greatest use. The muscles of tongue and cheek act combinedly to keep the bolus of food on the teeth.

To produce the most natural effect the centrals should be the lightest in color, and the cuspids a shade or so darker, with a difference in color of all the back teeth. I prefer on this account to set plain teeth wherever admissible—and nearly all lower cases are so—and use different shades and arrange irregularly. The lower incisor teeth are mostly

crowded, and I find to lap them over and distort them, even to a great extent, adds very greatly to their natural appearance. Don't be afraid of getting any case too irregular; very few natural sets can boast of perfect symmetry.

After the teeth are fixed temporarily on the plate they should always be tried in the mouth to see if they are perfectly correct. As the mouth is more yielding in one part than another, the closing of the jaws rather firmly will allow of slight readjusting of themselves on the wax. If, when finished, they are found not to articulate properly—which is sometimes the case from the soldering or vulcanizing—have the patient bite on a strip of wax placed between the grinding surfaces to show the relation of each. Then put this back into the articulator and rearrange the grinding surface. It will be found to need but a trifling alteration.

The false movement of the lower jaw at the condyles is found in nearly all persons who have had but one or two teeth remaining in the front arch, to reach which the jaw is thrust forward and laterally; and when artificial ones are placed in the same, old movements are continued until their attention is called to it. It can be corrected without any special arrangement other than following the law herein laid down.

The Equilateral Triangles within the Main Triangle—The outline drawings in Fig. 326 may be thought *ideal.* But any one at all acquainted with geometry, who has followed me in my argument and description, must be struck with wonder at the marvellous ingenuity of the contrivance based alone on the equilateral triangle. It will be seen that perfection must be the result, since each part is complete within itself and the whole supporting each individual part.

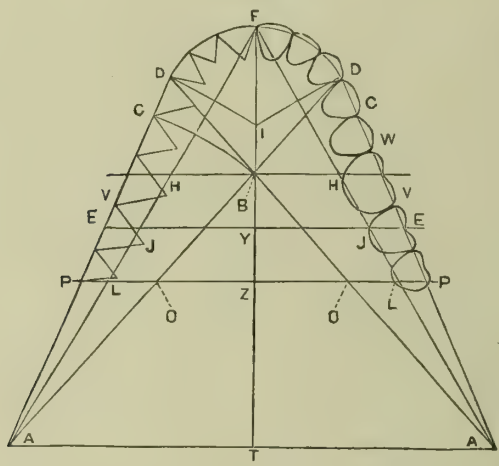
How have I arrived at this divination? The law is based on the measurement of over two thousand human skulls. First, make an equilateral triangle 4 inches each angle, A, A, F; draw a line from T to F. What is the guide to form the arch? Know the actual width of the superior central, lateral, and cuspid at their greatest diameter from mesial to distal surfaces—say $\frac{13}{16}$, as in Fig. 326. Measure this off with the dividers, and place one arm at F, and describe an arc from D to D through I. Then place dividers at I, and intersect the line just made from F, and it will be found that at D will be the extremest point of the arch D, F, D, and will be the distal surface of the superior cuspid. Place the dividers at I, and describe the arc from D to D through F, which will constitute the normal and positive arch of the superior jaw. There will be an equilateral triangle from D, F, I on either side of the mesial line at F. The same will be found the base of each superior incisor.

Next draw a line from A to D on either side, which will be the guide for the bicuspids and molars as to width and depth. Then, by placing the dividers at A and B, describe another arc to C, which will give the width of first superior bicuspid. The line from A to D passes through its palatal base, and will pass through centre of base of triangle of this tooth.

Form another triangle by drawing a line from H to H, through B, which will pass through the centre of the first molar, and will give the width between their palatal surfaces or their depth or thick-

ness. Placing the dividers at I and F, we intersect the line from F to T at Y. Draw a line through Y to E, E, forming another equilateral triangle. From B to F is now the radius of another arc, which intersects the line from D to A at V, and the line A to D at O. A line now drawn from E to E through Y intersects the centre of the second molar at E, E. Get half the distance between the points at E on the line from D to A, and the width of the first molar is made, and also the second, which is the angle of the equilateral of each. This leaves room between

FIG. 326.



the first bicuspid and first molar, and is the width of second bicuspid: or it is shown by placing the dividers at A and Y, and intersecting line from D to A at W, same as from B to C, for the first bicuspid's width. The distance from D to D is the same as from D to the distal surface of the second molar. P to P through Z forms another equilateral triangle, giving the wisdom tooth's place in the arch.

The arrangement of J and K (Fig. 324) on the left shows the teeth in the act of mastication, while on the right M and N (Fig. 323), the inner cusp of molars of the upper and outer of the lower molars come in contact when not in use. There is double the surface touching at every lateral movement.

Fig. 323 shows right side, as at M and N, and Fig. 324 that of left side (J, K) in action from the mesial line to the last molar.

Fig. 320 shows both bicuspids and molars in normal relation.

In conclusion, let me again impress all with the importance of cultivating mechanical art in our calling; for I can assure the reader that it will pay tenfold in increasing his usefulness as an operator in every department, and in giving him powers of conception, and lead the way to original ideas and more practical development.

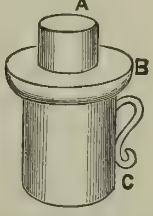
METALLIC DIES AND COUNTER-DIES.

By WILLIAM H. TRUEMAN, D. D. S.

There are three methods usually described for making the metallic dies and counter-dies used for stamping up dental plates: First, the dipping process, in which the counter-die is made first, either by pressing or dipping the well-dried plaster cast into the melted metal or by pouring or dashing the melted metal upon it. In either case the plaster cast is usually destroyed.[1] The die is made by pouring metal into the counter-die. Although considerable space is usually occupied in describing this process in works upon mechanical dentistry, I have never met with any one who practised it, and question if it was ever used to any extent. This and the next method, in which the die is obtained by pouring the metal directly into the impression taken from the mouth, are open to the same objections. In both of these processes type-metal or some form of fusible metal—an alloy melting at a low temperature—is necessarily used. All the alloys I have seen recommended possess far less hardness and strength than zinc. It is usually impracticable by either method to obtain more than one accurate die; and as it is absolutely impossible to swage a gold or silver plate to fit well without using more than one die

[1] "Take an iron ladle of hemispheric shape and capable of holding at least a pint and a half of fluid; melt in it as much lead as will nearly fill the ladle. Into this molten lead immerse the plaster cast, and depress it by laying weights upon it till the points of the teeth shall be sunk about one inch below the surface of the melted lead in the ladle. When cool, immerse the whole in water and carefully remove and wash away the plaster. Cover the surface of the lead with which the other metal is to come in contact either with the smoke of a lamp or with whiting laid on wet with a brush, in order to prevent the adhesion of the melted tin which is to be poured into it. Dry the leaden mould well, and place it on a vessel filled with water or wet sand, so that the lead shall be sunk in the water or sand about an inch, to prevent its fusion when the tin shall be poured into it. Surround the impression of the teeth in the mould with a rim of tin, copper, or brass an inch or more in width, as in Fig. 327. Fill the rim, A, with melted tin just at the point of fusion or at such a temperature that it will not char dry pine chips or shavings; at any temperature higher than this there will be danger of fusing the lead and thus uniting the metals into one mass. But inasmuch as tin fuses at a lower heat than lead, and as the cold water or wet sand will maintain the low temperature of the lead, there will be no danger of spoiling the cast in case the foregoing rules are carefully regarded. The two metals when cool must be separated by means of a heavy hammer, assisted when necessary with wedges of iron" (Solyman Brown, M. D., D. D. S., *The American Journal and Library of Dental Science*, vol. ii. (1841), p. 170).

Fig. 327.



A denotes the metal ring; B, the leaden mould; C, the vessel filled with water or wet sand.

when that is made of so soft a metal, I do not consider them of any practical value. If it is important to obtain an accurate impression, and from this a cast or model as nearly as possible an exact counterpart of that portion of the mouth over which the denture extends, I consider it equally important, in plate work, to preserve this cast uninjured and in as useful a condition when the case is done as when it was first made.

For these reasons I have simply referred to these methods without entering into detail, and shall confine my remarks to the more practical method, in which the metal is poured into an impression of the cast taken in moulding-sand. By this means we can obtain any number of duplicates desired, the cast is not injured, and harder and more serviceable metals may be used.

In the early history of mechanical dentistry the dies were usually made of brass, and, as but few dentists had conveniences for working so refractory an alloy, they were generally made by the brassfounder. The introduction of zinc for this purpose brought their construction within the resources of a dental laboratory, and was one of the factors that assisted in making the change from the old plates held in place by spiral springs or clasps to those now so generally used and known as suction-plates.

A good die, next to an accurate cast, is all-important to secure a well-fitting plate; and however skilful the professional founder may have been, he lacked that practical knowledge necessary to secure the desired result. Apart from its convenience, the ability to construct his own dies enabled the dentist to produce far more accurate work; he knew what was wanted better than the brassfounder, and appreciated and secured accuracy in detail to a greater degree. Although a number of metals and alloys have from time to time been recommended for metallic dies and counter-dies, none have proved so generally useful or have been so extensively used as lead and zinc. Zinc is the hardest metal that the dentist can conveniently melt; it is sufficiently hard for the purpose, possesses a fair degree of toughness, and stands the impact of the hammer better, perhaps, than any other readily-fused metal or alloy. It is easily melted without the use of a specially constructed furnace, and yet its fusing-point is sufficiently high to permit the use of lead for the counter-die without risk of union between the two, and this without the precautions needed when Babbitt metal or other like alloys are used. Lead has all the properties desired in the counter-die: it is soft and yielding, yet is hard enough to force the plate well into place and to stand the duty required of it. Lead and zinc, from the slight affinity they have for each other, the difference in their fusing-point, their cheapness, and also from their being so unlike in appearance that they are less liable to be accidentally mixed, seem specially adapted for dental dies and counter-dies.

The heat required for melting zinc, about 770° F., is readily commanded in a dental laboratory, an ordinary stove, a charcoal fire, or a gas furnace being quite sufficient. The great objection urged against it is its contraction in cooling. At first sight this seems a decided fault, but in practice it is of but little moment.

We must bear in mind that the mould is always a trifle larger than

the cast, and also that, no matter how accurately the plate is swaged, it is always a trifle larger than the die on which it is made, so that one error corrects the other; and I have found no difficulty in swaging plates with zinc dies to fit the plaster cast accurately. In several dental laboratories with which I am familiar, and which are doing a large amount of plate work, zinc is used exclusively with entire satisfaction. To obtain the best results the zinc should be used with care and not be overheated. If it is allowed to become red hot, it never works quite so well afterward. It oxidizes rapidly at that temperature, and apparently throughout its mass, so that it is less fluid and does not pour so well or make so smooth a die. I have found no way to restore it when in this condition: adding wax or fat or charcoal powder to the melted metal to reduce or separate the oxide has been recommended, but I have found very little real improvement resulting from their use. It is far better to prevent than to cure; and to this end it is well to frequently empty the melting-pots, so as to remove the dirt and oxide that form on the bottom, and not to have the fire so hot that before the mass is melted some portions become overheated. It is very important to have separate pots for the zinc and lead, and to be very careful that they are not interchanged. If zinc and lead are melted together, a portion of the lead unites with the zinc and cannot be separated from it; this impairs it for our use. When the accident occurs the lead that does not unite with the zinc is found at the lowest part of the mould, and if it is turned out just after the zinc has set, the lead, melting at a much lower temperature, will be still fluid and run out; if this does not happen it makes a soft place in the die and renders it useless. To separate them, make a cone-shaped mould in the sand that will hold the metals in fault; into this pour the metals heated a little above their melting-point. The lead, being heavier, will sink to the bottom, and we may lift out the zinc as soon as it is set, leaving the lead, or we may let them both set and cut off the lead when it is cold.

There is always a risk in using metal that has been mixed, so that it is a question whether it is not better to throw it away than to risk losing valuable time by having a die spoiled. After a time zinc loses its fluidity and becomes thick and pasty, and does not pour well. This is probably owing to the oxide, dirt, etc. becoming mechanically mixed with it; when this condition is reached, it is better to lay it aside and begin with fresh zinc, rather than to attempt to restore it. Do not mix the old with the new, as the worn-out zinc will seriously impair its working qualities.

Dr. L. P. Haskell[1] calls attention to the use of Babbitt metal for dental dies and counter-dies, claiming for this alloy, if well made, greater accuracy on account of its not shrinking, and greater convenience in use on account of its low melting-point. He gives the following formula and directions:

"Copper,	1	pound;
Antimony,	2	"
Tin,	8	"

[1] *Missouri Dental Journal*, vol. xiv. p. 19, Feb. 15, 1882.

Melt in a crucible—in a forge or other intense heat—first the copper, next the antimony; then remove from the fire and add the tin, and turn off at once into small ingots; remelt, so as to thoroughly mix. After moulding and casting the Babbitt-metal die, when it is cool wash it over with whiting. For the counter-die use lead with about one-eighth tin added, stirring until it begins to thicken, and pour. With these precautions there is no danger of the dies uniting." When the Babbitt metal begins to thicken with use he recommends adding a little tin to restore its fluidity. He credits Dr. D. H. Goodno of Boston with recommending it for this purpose about 1852.

When zinc is used, two dies and counter-dies are needed to properly swage a plate; the first used is always more or less bruised on the more prominent points. The plate should be really made on the first, the second being reserved to give the finishing touch to the fit; if the previous work has been done well, it seldom requires swaging upon this more than once. When softer metals are used, more dies are needed, and this introduces another difficulty. In swaging the plate upon so many different dies it is apt to slightly change its position and to become "stretched." When this has taken place it is very difficult to secure an accurate fit, and the plate will be apt to "warp" in soldering. I have been unable to see any practical advantage in the various fusible or non-shrinking alloys that have been recommended from time to time. The convenience of a melting-point lower by a few degrees is offset by the expensiveness of these alloys, the greater risk of the dies uniting, and the care needed in handling them on account of their softness or brittleness. The advantage of non-shrinkage is secured only when the alloy is in definite proportions; this is readily secured at at first, but on account of unequal oxidation or accident or the change occurring in these alloys from repeated remelting, it cannot be maintained with certainty. When it is considered that the contraction of zinc in a die measuring two inches from outside to outside of the alveolar ridge is only between two and three one-hundredths of an inch, I fail to see any real advantage these unstable alloys have over the simple metals lead and zinc.[1]

Within the last few years non-metallic compounds, known as Spence's metal for dies and Darcet's metal for counter-dies, have been introduced in Europe in connection with presses for constructing dental plates, designed by Dr. Telschow and modified by M. Saussine. These

[1] *Contraction of Zinc.*—"According to my experiments, a bar of zinc five inches in length contracts in casting one-eighteenth of an inch, or one-ninetieth of its length. This is a little more than is usually allowed in zinc castings. I have been informed by a person who casts large quantities of zinc for various purposes that he has his patterns made one-eighth of an inch to the foot larger than he wants his castings to be.

"In estimating the contraction I do not take into consideration the settling in the centre on the top of the cast, which we see when the castings are made in an open mould, as we usually make them, but the contraction that takes place on the surface that is intended to be used. Now, allowing an ordinary-sized cast to be two inches across and two and a half inches in length on the surface where the plate is to be made, we have a contraction of the one forty-fifth of an inch across and the one thirty-sixth of an inch in length; but we must bear in mind that the cast is not this much smaller than the mouth, for we have an expansion in the plaster cast of one-fourth of this amount. Zinc contracts four times as much as plaster expands" (Dr. T. L. Buckingham, *Dental Cosmos*, vol. ii. p. 144).

compounds are quite fusible—Spence metal, a compound of sulphur, bismuth, antimony, etc. (the exact formula, I believe, has not been published), fusing at 239° F., and Darcet metal, a similar compound, fusing at 201.2° F. These compounds make hard but very brittle dies; they cannot be used with the hammer; the plate is swaged into shape between them in a screw or hydraulic press especially designed for the purpose. It is claimed that a more accurately fitting plate can be made by their use, as, in the first place, the dies are made by pouring the compound into an impression or mould taken either directly from the mouth or from the plaster cast in plaster, clay, wax, gutta-percha, etc.; the compound not only melts at a low temperature, but has the property of immediately hardening as soon as it comes into contact with a colder body, thus permitting the use for the mould of a variety of materials more convenient to use, and giving a sharper and more accurate impression than those usually used in making metallic dies.

Secondly, it is also claimed that, practically, these compounds neither expand nor shrink in setting.

In order to make a die in Spence metal the operator should proceed as follows: Take from the plaster cast of the patient's mouth a fresh impression with any of the gutta-percha or other like impression-compositions where there is a probability of its dragging; where this is not to be feared, clay may be used. The impression must be well coated with a solution of soft soap in water. Be careful in applying the soapy mixture to a clay impression not to change the form of the more prominent parts. The soapy solution prevents the Spence metal from adhering to the impression. Now cast the Spence metal, having previously melted it over a slow fire, continually stirring it while in fusion. If the Spence metal is too much heated it thickens; it is then necessary to remove it from the fire and wait a few moments in order that in cooling it may regain its fluidity; the metal must not be poured into the impression until upon agitating the melting-pot a very slight coating is seen on the sides of the vessel. There is no contraction in Spence metal, or at least if there be any it shows itself in the centre of the mass: when nearly the whole mass is crystallized the middle part sinks, the border or sides remaining in absolute contact with the impression; then the cooling gradually takes place from the side to the centre. Enough of the Spence metal is now run into the central hollow which forms in the die to make a solid mass of metal.

On account of the brittle character of the compound the dies are encased in a strong malleable cast-iron box or flask (see Figs. 328, 329, 330), constructed somewhat like a vulcanite flask, in two sections, and provided with strong guide-pins (shown at A, Figs. 328, 329), so that when placed in the press the two halves are brought accurately together. When the die is taken out of the mould or impression, it is placed upright in the lower part of the flask or box (Fig. 330), where it is held in place by two or three little supports, heated, and thus inserted into the Spence metal with their opposite ends bearing against the inner border of the box. By cutting the props or supports the required length the die can be placed at a convenient height; only the parts necessary for stamping the plate should remain above the edge of the

box. Now fill the space between the die and the flask with Spence metal, which should be poured rather hot, but still in quite a fluid state.

After cooling, correct any inaccuracy in the die, and fill with clay the parts that are undercut and which might be injured in withdrawing the counter-die; place the upper section of the flask (Fig. 329) in posi-

Fig. 328.

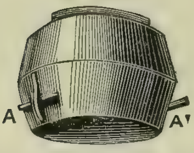


Fig. 329.

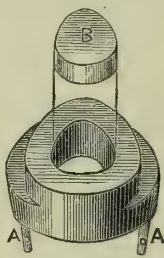


Fig. 330.

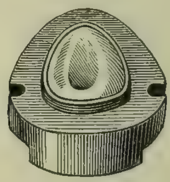


Fig. 328. Flask maintained closed by means of the pins A, A.'
Fig. 329. Flask for counter-die of Darcet metal: A, A', the guide-pins; B, the cast-iron follower placed between the counter-die and the bed-plate of the press.
Fig. 330. Flask containing the die, in Spence metal.

tion, with the guide-pins fitting into the grooves made in the lower section to receive them. It is necessary to line the sides of the upper section with a band of thin leather, so that when the metal is cool it may be easily withdrawn.

The Darcet metal for the counter-die may then be cast as cool as possible, for although it melts at 201° F., when once melted it has the property of quickly acquiring a much higher temperature; therefore to avoid injuring the die it should be allowed to cool and may be poured in a somewhat thickened state. As soon as the counter-die is poured, the follower (B, Fig. 329) fitting the upper part of the flask is pressed down upon it. This follower is made of iron, and is intended to protect the Darcet metal from injury. After cooling separate the flask, and the two dies can be separated by inserting the blade of a knife between them. They are now ready for use. In simple cases the counter-die may be made of gutta-percha. Being confined in the flask under the steady pressure of the press, it is found to make a good counter-die where there is not much undercut.

These compounds have been used only to a very limited extent in this country, and, as they require a somewhat expensive press and cannot be applied to all cases, it will be some time before they supplant the usual methods.

I will now proceed to describe the methods usually employed for obtaining metallic dies and counter-dies with the use of moulding-sand.

Preparing the Cast.

After the impression has been removed from the cast and its imperfections corrected, mark upon it the outline of the plate and the position of the vacuum-chamber, clasps, etc. In partial upper cases, either

clasped or suction-plates, it is advisable to make a shallow groove along the posterior line of the plate on the plaster cast before the metallic dies are made, so that when the plate is swaged this edge will press hard against the roof of the mouth and be less perceptible to the tongue; it also prevents the entrance of food, etc. The same may be done in full upper plates, especially if the integument is soft and yielding. Before doing this, however, the mouth should be carefully examined, and if any portion of this line is found hard and rigid it will not answer to remove any plaster from the cast at that point. In some cases, where the centre of the mouth is unusually hard and unyielding in comparison with other portions of the palatal surface, it is necessary to add a slight coating of wax over the corresponding part of the cast, so as to relieve the pressure at this point, which pressure would otherwise prove a source of discomfort when the plate is worn.

This marking of the plate-line is necessary in order that we may know how much of the surface of the cast will be covered, and thus how much is required to be accurate in the metallic die. When this has been determined examine the cast and see that it is level; if it is not, make it so by adding to or cutting from the bottom. If it is not level, the dies will have the same defect, and, no matter how accurate they may be in other respects, it will be a difficult task to make a plate upon them that will fit: the tendency will be to strike the plate toward that part of the cast lowest in the counter-die, and the result will be a rock or "spring" very difficult to work out. In trimming the body of the cast into proper shape it is desirable to avoid having it much larger than the plate requires; at the same time it is best to have a little margin at the back part—say in full plates at least one-eighth of an inch, and in partial plates not less than one tooth beyond the back edge of the plate-line. Make the sides slope slightly, so that it will readily leave the sand. As far as possible avoid all sharp undercuts. If they are not needed fill them up with wax; if they are, cut away the plaster without encroaching upon the part to be covered by the plate, so as to round them out and leave room for a larger body of sand. A little judicious, thoughtful care in shaping the cast will save a great deal of trouble in the after-operations. When any filling up is needed I have suggested wax, preferring it to plaster, as it is often desirable to alter it while making the mould and to remove it entirely after the dies are made.

The cast is now ready for varnishing. For this purpose either gum-shellac or gum-sandarac dissolved in alcohol may be used; I prefer sandarac, as it sinks into the cast and is not so liable as shellac to scale off, and (being transparent) is more sightly. The varnish should be quite thin; it may be prepared by placing in a pint bottle, say, half a pound of either gum and filling up with alcohol. If it is needed for immediate use, place this in a vessel of water and heat up to about 150° F. for a few hours, or it may be allowed to stand in a warm place for a few days, occasionally being shaken. This is the stock bottle, and should be kept tightly closed to prevent evaporation of the alcohol. If the bottle has a glass stopper, keep it well coated with

wax, lard, or tallow to prevent its sticking. As the varnish is used add alcohol from time to time until the gum is entirely dissolved. For use keep a small quantity in a wide-mouthed bottle (say a mucilage bottle), and dilute it as needed. The object of the varnish is not only to protect the cast, but also to give it a surface to which the damp moulding-sand will not adhere. I recommend varnishing the cast at this stage, although it may not be quite ready for the moulding-bench, as it protects it from injury and makes it more cleanly to handle. One thin coat of varnish is all that is now needed; it is desirable to use the varnish quite thin, so that it will sink into the cast and not form a thick coating on the surface. It may be necessary to repeat the varnishing, perhaps several times, before a satisfactory mould is obtained, and if the varnish is thick not only are the fine lines filled up, but it is apt to scale off and injure the usefulness and appearance of the cast.

If a Gilbert[1] or chased vacuum-chamber or suction-cavity is desired in the plate, the cast should be prepared for the purpose before making the metallic dies, in either of the following ways: 1. The form of the chamber may be cut from the impression before the cast is made; this I consider objectionable, as when so done it is difficult to accurately determine its position and depth. 2. A pattern may be cut from sheet wax the size and shape desired, and adjusted in the mouth before the impression is taken. The wax is brought away with the impression, and if removed before the plaster is poured in will be reproduced in plaster on the cast. This seems a cumbersome and uncertain procedure, without any obvious advantage. 3. A pattern may be cut from sheet lead or tin of the required form and thickness, be placed in proper position, and pressed down with the fingers or a burnisher until it conforms to the contour of the cast; it is then fixed in place either by a small tack driven through it into the plaster or by a little cement. 4. A sheet of wax a little thicker than the desired depth of the chamber may be fitted to the palatal face of the cast: cut from this, at the desired point, the form of the cavity, and after roughening the exposed portion of the cast and wetting it with water, fill this with plaster, and when hard remove the wax and trim the raised portion to the proper form.

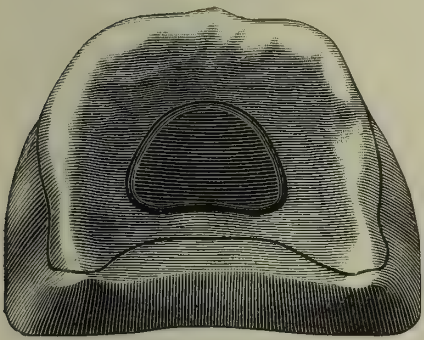
I do not approve of any of these methods, nor yet of the use of plaster for this purpose: as a rule, wax is preferable in making any additions to the cast that are desired in the metallic die. It is more easily used than plaster, and answers the purpose equally well, and when done with is readily removed without injury to the cast The simplest way to form the chamber is to place a few drops of melted wax on the cast so as to secure adhesion, then add softened wax, and trim into shape with the wax-knife. In carving the wax give it a slight bevel, so that it will leave the sand freely, and when finished make a slight groove all round with a sharp point, accurately following the margin of the wax. This will facilitate striking it up to a sharp outline, and thus increase the usefulness of the chamber. The chamber formed in this way leaves a sharp impression in the sand, and has the further advantage that any changes in its form found necessary during the

[1] Invented by Levi Gilbert of New Haven, Conn., and patented by him Feb. 15, 1848.

moulding process are readily made. Two general forms of the vacuum-chamber are represented in Figs. 331 and 332.

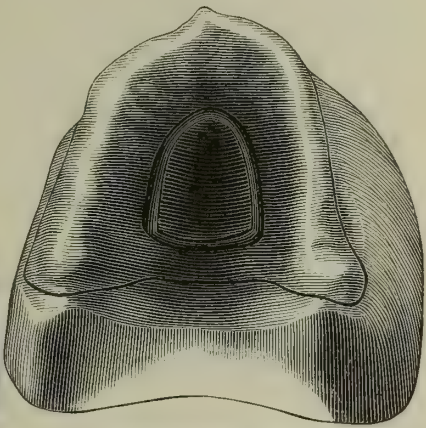
If the cast is for a partial plate, examine the teeth and the spaces between the teeth, and see if they are likely to come out of the sand clear; if the teeth lean or are so shaped that they will not draw, correct this by adding a little wax just at the point needed and trim it off smoothly. Use no more than is absolutely required, as all that is added beyond

FIG. 331.



Form of Vacuum-cavity for a broad palatal arch.

FIG. 332.



Form of Vacuum-cavity for a narrow palatal arch.

this will, when reproduced in zinc, have to be cut away from the die. It may be best to make a trial-mould first, then add the wax where it is seen to be needed. Practice and management enable an expert to get a good impression from casts where the undercut is quite marked: it is an art well worth trying to acquire.

Occasionally we have a cast where the ridge overhangs, or where there are deep or sharp undercuts, or, especially in partial lower cases, where the teeth lean so much that it is impossible to get a good impression in the sand, and where to correct the difficulty by adding sufficient wax would give a very unsatisfactory die. In these cases the difficulty may be overcome by the use of sectional flasks or by the use of plaster cores. As a rule, cores will be found the more satisfactory in all respects. To prevent "bubbling"[1] it is necessary that they should be perfectly dry before the metal is poured into the mould of which they form a part; therefore some ingredient must be added to the plaster to prevent its

[1] Any moisture in the mould when the hot metal is poured in is immediately converted into steam. If the mould is made of sand and not packed too solidly, and there is but little moisture present, the steam escapes through the sand and no harm is done. If there is much moisture, or the mould is made of plaster, or of sand packed tightly, or of any non-porous substance, the steam is compelled to escape through the metal, producing the effect known technically as "boiling" or "bubbling." Unless it is very slight the die is usually spoiled, a deep depression being produced about the centre of its face. Sometimes the metal is raised up a slight distance from the centre of the mould so evenly that the defect is scarcely noticeable until the plate is swaged upon it. Where the injury is slight in a die hard to make, it may be passed in the first die, but it is not safe to use a die for finishing where this has taken place, even though no injury may be visible.

shrinking from the heat required to drive off the moisture. If sufficient time could be allowed to dry it very slowly, then plaster alone would answer, but as that takes a number of hours, the sand of the mould by becoming dry would lose its cohesion and render it (the mould) useless. If the cores are dried before the mould is made, there is great risk of the plaster breaking, as the well-dried plaster is very brittle and friable; and, again, by long contact with the damp sand it takes up moisture, and would spoil the die through "bubbling" as readily as though it had not been dried. Therefore, in practice I add about an equal part or two-thirds of either pulverized soapstone, moulding-sand, pumice-stone, whiting, asbestos, or any similar substance that will unite with the plaster and enable it to bear a red heat without shrinking. Each operator has his own favorite formula, but there is really little choice: provided we get a mass that readily parts with its moisture, has a smooth surface, and sufficient strength to bear the necessary manipulation, it matters little what is used; I have had good results with all.

After carefully examining the cast decide what parts cannot be accurately moulded in the sand, and after oiling the cast build on the prepared plaster as may be needed. When hard, trim it so that the cast with it in position will readily leave the sand, and also so shape the core, by forming upon it a shoulder or projection, that when the mould is made it can be removed from the cast and be accurately adjusted to the imprint it has left in the sand. In shaping the core, care should be taken not to leave any thin edges, as they may be burnt or broken off in drying. Sometimes two or more cores may be needed for one cast, and in very difficult cases they may really form an impression made in sections.

It is best to avoid the use of cores wherever possible: they are more accurate and reliable than sectional flasks, but there is always a risk where they are employed. The plaster may warp in drying, it may be misplaced when returned to the mould, or may change its position when the metal is poured in, so that they do not give as sure a result as an ordinary mould made entirely in sand. In some cases of overhanging ridge, either upper or lower, a slight filling up of the deeper portions with wax will give a die readily made accurate by a little carving. When the surface is uneven and irregular, then cores are to be preferred. We have not entered into detail or attempted to describe any particular class of cases: they are so varied that each calls for its own special treatment and must be left to the workman's judgment. It is best to make the cores large, as they are then less liable to be misplaced in the mould and to be displaced in pouring. Their easy removal from the cast must also be considered. They are often needed in full lower cases where the ridge leans in all around. In such a case an accurate mould in sand is impossible, and yet we may often save time and labor by using wax and getting the best result we can for the first die, making the second or finishing die with cores. In such a case I suggest letting the core take in the entire alveolar border on the inside, making it in two pieces, each extending about one-third the distance between the condyles at the back part, and coming to a point at the median line where they meet, leaving a triangular space between them to be filled

with sand. By this arrangement we get an accurate die and do not risk breaking the cast, as would in all probability occur if it was made in one piece.

I object in all cases to mutilating the cast, and consider the plan so often recommended of cutting off the teeth in difficult partial cases, so as to more readily get an accurate die of the part to be covered by the plate, as unworkmanlike. Where a single tooth is in fault, or perhaps one on each side, in very difficult cases it may be advisable to break them off carefully, cover the fractured surfaces on the cast with soft wax, so as to keep them clean until the die is made, and then cement the teeth in place again. By this plan the cast is not really injured. An excellent plan, especially in partial lower cases, is to take from the cast a plaster impression, in sections, of the portion to be covered by the plate, not letting it extend over or include the teeth; from this make a duplicate cast which may be used to obtain the dies and make the plate. This may often be done in less time than is required to make cores, and preserves the original cast intact.

If it is desired to strike up a rim in one piece with the plate, as is usually done in continuous-gum work to avoid the use of solder, it is necessary to form a shoulder all round the cast, conforming to the line of the plate and projecting about one-eighth of an inch, as shown in Figs. 333 and 334. This may be made of wax, but plaster is much to

FIG. 333.

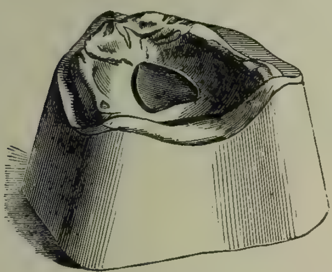
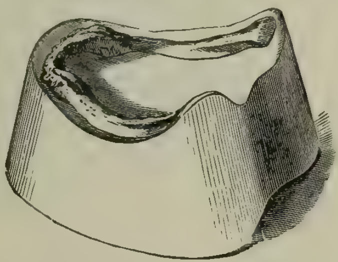


FIG. 334.



be preferred, for this reason: the thin platinum plates used in continuous-gum work would be cut through if the effort was made to drive them into this sharp angle with a chaser, as we would with gold or silver; therefore, after striking them as accurately as possible, the rim is finished by burnishing on the plaster cast, which can be easily done if the rim or shoulder is also of plaster, but not so well if it is made of wax.

The shoulder may be built up in the following manner: First, arrange a rim of wax—or, in other words, make a wax plate having the wax at its edges a little thicker than the width of the intended rim; carve this accurately to the lines of the plate, and give it a smooth, even bevel, the reverse of that which is desired in the plaster. (In upper as in lower plates this is extended all around; the upper plate is usually turned over at the back part to give it additional strength, and it can be "struck" to turn over more accurately than by any other means.) When this is done immerse the cast in water, so that the new plaster

will unite with it, and build on plaster, beating it well into the angle formed by the cast and the wax. When this is hard the wax is removed. If the work has been carefully done, the plaster will need but little trimming In making this "shoulder" for forming the rim, due regard must be had to so shaping it that it will readily draw from the sand. Sometimes a little change will make it far easier to mould, and yet not interfere with its usefulness. The addition of this shoulder makes it far harder to make an accurate die, and we do not consider it at all advisable except where it is desired to avoid the use of solder.

The cast, being fully prepared, should now receive another thin coat of varnish, and when this is hard it is ready for the moulding-bench. While making the mould, if it is found necessary to add to or remove any of the wax, or to cut away any part of the cast, the fresh surface should receive a coat of varnish; if this is neglected the sand will be apt to stick to it and injure the mould. The possibility of having to use the varnish quite often makes it important to have it thin, especially as thin varnish answers equally well and sets or hardens rapidily.

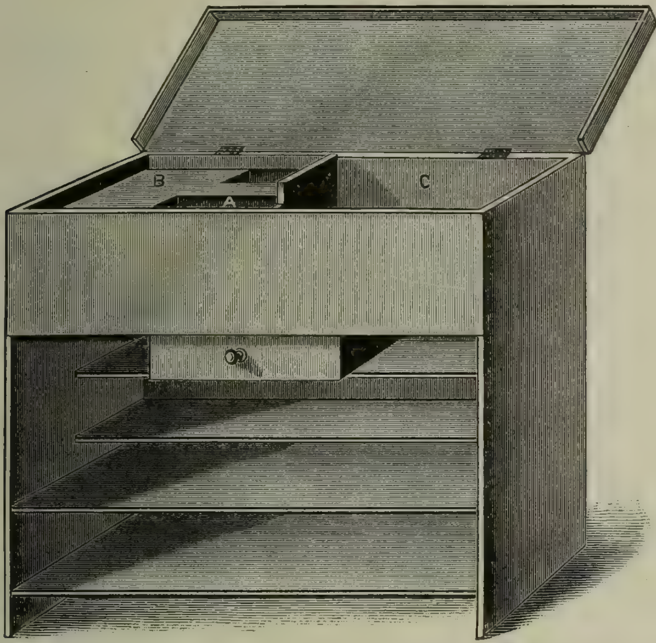
Making the Mould.

The cast being now ready, we proceed to make the mould. For this purpose I use the finer grade of sand used by brassfounders; or marble sand, a form of finely-pulverized marble to be obtained at the marble-yards, answers a good purpose. The marble sand is rather cleaner to use than moulding-sand, and as it does not pack so densely there is less trouble from bubbling; on the other hand, it is less cohesive, is apt to be injured if the metal is poured very hot, and as it dries rapidly it does not answer to let the mould stand long before pouring, or the weaker portions will be washed away by the metal and the cast come out rough and inaccurate. Whiting has also been recommended, but I have not found it satisfactory.

Where considerable plate work is done it is desirable to have a bench designed especially for this work, with boxes for the dry and wet sand, and shelves for lead, zinc, flasks, old and new dies, tools, etc. One I have used with satisfaction a long time (shown in Fig. 335) consists of a box with a tight-fitting lid hinged to one side. The box is divided into two compartments, and is lined with sheet copper. The compartment on the right hand (C) is for the damp moulding-sand ready for use. The left-hand compartment contains a fixed block (A) placed in the front right-hand corner: the face of this block is about six inches square and about an inch below the edge of the box. On this the moulding is done. The remaining portion of this compartment is covered with a movable cast-iron tray (B) on which the moulds are set when ready to pour. After the sand has been used it is passed into the box beneath through a square hole at the right-hand corner of the tray. By this arrangement the wet and dry sand is kept separate, and the tray is not encumbered with the sand that has been used. The tray, being made of cast iron, is not injured by the heat, and any metal spilled upon it is readily recovered. It is very desirable in moulding that the moulds already made shall not be jarred or shaken by the manipulation necessary in making others.

It often happens that the sand is broken away, yet is not so much displaced but that it may be accurately readjusted and a good cast obtained from it; in these cases a very little shaking would ruin the mould. In the bench referred to this is provided for by doing all the moulding on a solid block that is not directly connected with the tray on which the flasks are placed for pouring. Underneath the box is a drawer in which

Fig. 335.



Moulding-bench: A, moulding-block; B, iron tray; C, compartment for moulding-sand ready for use.

the tools used in moulding are kept, and underneath this, forming a stand for the box, are some four strong shelves, covered with sheet zinc to prevent wear, on which the flasks, new and old dies, zinc and lead, etc. are kept. The whole forms a very desirable arrangement for the purpose. If there is no special moulding-bench, the sand may be kept in an earthen basin or jar; the moulding may be done on a board, say two feet square, with a ledge all round. This takes up little room when not in use, and when needed may be laid upon the workbench or a table. The tools used exclusively for moulding are few in number:

1. *A Sieve.*—It should have meshes about twelve to the inch, and should be made preferably of brass wire, but iron will answer if it is kept where it will so quickly dry after being used as to prevent rusting. The sand is passed through this after being used, not only to break up the lumps, but also to remove any particles of metal that may have been spilled.

2. *The Flasks.*—These are boxes of wood or iron open at both ends, in which the mould is made. If made of wood, they should be from four to six inches square and four inches high. The wood should be

half an inch thick and well seasoned. The ends should be dovetailed, and the corners strengthened by a triangular piece of wood secured on the inside. The iron casting-rings sold at the dental dépôts in nests of four or five sizes make by far the most convenient moulding-flasks. They are smaller, lighter, require less sand, are of desirable shape and easily handled, and are not injured by the contact of hot metal as the wooden ones are. It is far better to obtain a supply of these than to "make out" with clumsy "wagon-boxes" or flimsy improvised affairs of wood that are continually breaking, and which are at best seldom satisfactory.

3. *The Casting-Rings.*—These are rings of iron used in making the counter-die. For this purpose the rings just referred to are by far the best; where they cannot be obtained rings may be made of hoop iron three inches wide, bent to conform to the usual shape of casts. They should be made a little larger at one end than the other, and the edges brought near together, but not overlapped; when in position the joint is covered from the outside with damp moulding-sand; if they were overlapped the metal running into the joint would be difficult to remove. They are also used to put over the mould when it is desired to make the die thicker than the plaster cast. Several sizes are required.

4. *A Small Brush.*—A common shaving-brush or a small paint-brush will answer. This is used to brush the sand from the cast in moulding and in making the counter-die.

5. *A Point.*—A worn-out four- or five-inch half-round bench file answers admirably. The shank end is used to lift the cast from the mould; the other end takes the place of a moulder's trowel in repairing moulds. I use this in preference to more elaborate arrangements designed to take its place.

6. *A Wooden Rule.*—This should have straight edges, be from four to six inches long, and just large enough to be rigid, say about half an inch wide and one-fourth inch thick. This is used to level off the sand in making the mould, and also to gently jar the cast before attempting to remove it.

7. *A Glass Tube*, of suitable length and about a quarter-inch diameter, will be found useful in blowing out the sand that may have fallen into the deeper portions of the mould; it is more convenient than the bellows which moulders use for this purpose.

8. *An Iron Spoon.*—The purpose of this is to clear away or remove the dross or oxide from the surface of the metal just before pouring.

A camel's-hair pencil, a small hammer or mallet, and a small cold-chisel are also needed. These, with the necessary melting-pots, tongs, etc., are all that are really required for this work.

There are in the market several forms of flasks and casting-rings fitted to each other, and designed to give the die and counter-die a suitable shape. They are good in some cases, but are by no means essential: while they give the die a desirable shape, there are disadvantages connected with them, and so many cases occur in which they cannot be conveniently used that I think it better to learn to accomplish the same result by other means. There are also sectional flasks, designed for moulding difficult cases; in careful hands these give good results, but are so liable to accident and require so much care that I think

it practically better in these cases to make cores. While these appliances have merit, they are more or less complicated, and the results obtained by them are no better than can be as readily obtained by simpler means; so that I question their real usefulness.[1]

[1] *Bailey's Flasks for Making Metal Dies.*—It consists of two semi-elliptical rings of iron, one nearly straight, the other a truncated cone, with four ears or keys, jointed so

FIG. 336.

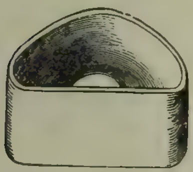
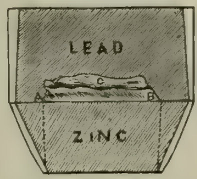


FIG. 337.

FIG. 338.



as to fit together. The straight ring, Fig. 336, is used as a casting-box for the sand as well as a form for the lead; the other, Fig. 337, gives the proper shape to the zinc. Fig. 338 shows the die and counter-die in position in the flask. There are two sizes and shapes, adapted for upper and lower cases. The smaller one is three and a half inches across the base or straight side, and three and a quarter inches in its longest diameter; the height of the straight ring is one and three-quarter inches—the conical one, one and a quarter inches. The large one is broader at the base to suit the divergence of the lower jaw; otherwise it is essentially the same. It is recommended to make the plaster casts quite thin for use with these flasks. They are used as follows: Place the plaster cast on a level surface; invert over it the flask, Fig. 336, with the joint edge down; pack the sand and remove the cast in the usual manner. In pouring, after filling the mould in the flask made from the cast, place the casting-ring, Fig. 337, in position over it, and fill it up immediately with the molten zinc. When this is set, turn the flask over so that the face of the die is up (C, Fig. 338), remove the flask, knock all the sand out of it, and after brushing the sand from the face of the zinc die replace it in its former position and pour in the lead. The design of this arrangement is, first, to give the zinc die a proper shape, and, second, to form a ledge (A, B, Fig. 338) extending beyond the face of the die on which the counter-die rests; this is intended to prevent the die tilting while striking up the plate. (See *Dental Cosmos*, vol. iv. p. 420.)

Sectional Moulding-Flask, invented by George E. Hawes of New York City.—Fig. 339 represents the lower section of the flask, slightly open, to show the joints; Fig. 340 is the upper section. When ready for use the lower section is closed and confined by a pin, and the plaster model placed in it, as represented in Fig. 341.

FIG. 339.

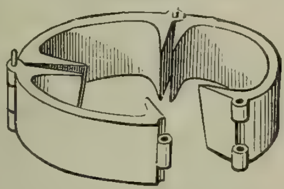
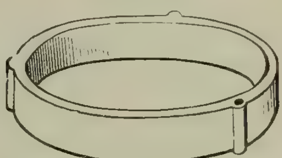
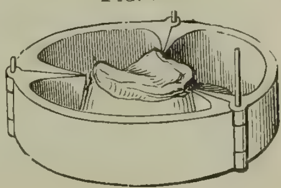


FIG. 340.



If the model is considerably smaller than the space between the flanges, projecting in toward it, small slips of paper may be placed in the joint extending to the sides of the model, to part the sand when opening the flask for the removal of the cast. The sand may now be patted around the cast up to the most prominent part of the gum, and it should be finished smoothly around it, descending toward the model, so as to form a thick edge of sand for the more perfect parting of the flask. The sand and face of the model must now be covered with dry pulverized charcoal sifted evenly over the whole surface. The moulders keep it in a bag which they shake over the flask. When this is done the upper section of the flask is placed upon the lower and carefully filled with sand. It is then raised from the lower

FIG. 341.



We are now ready to make the mould, as it is technically termed. First see that the sand is in order. It should be free from lumps, bits of metal, plaster, etc. It is always best to sieve it immediately after it has been used, and then sprinkle over it enough water to keep it in proper condition, and every night before leaving the workroom see that it is damp enough to be in working condition the next day. If it is allowed to become quite dry and the water added just before using, it is not as cohesive; the very dry portions do not take up water readily, and, although there may be more water mixed with it than there should be, it will be friable and apt to make a rough mould; with sand in this condition a cast will drag badly that would leave the sand clean if it was in good order. On this account it is better to keep the sand in a water-tight vessel of earthenware or metal or metal lined, and tightly covered. In a wooden box it becomes dry at the edges, and with the small quantities usually found in a dental laboratory this impairs very much its working properties. Oil has been proposed as a substitute for water, in which case it is recommended to add one quart of oil to a peck of sand. It is claimed that the sand so prepared is always in immediate readiness for use. A solution of glycerin has also been suggested for the same purpose: I have not been impressed with the value of either. At best, work at the moulding-bench is not over-cleanly, and the addition of oil, etc. is no improvement in that respect; while the smell from it if the metal becomes a little overheated, as it often may, is a decided objection. If the precaution is taken to get the sand in good working condition a few hours before it is to be used, so that it has time to become "mellow," or, if it is used often, to always keep it in order, water is by far the best. If the sand is dry and wanted for immediate use, add a sufficient quantity of water, and thoroughly rub it up with the sand between the hands, so as to get it evenly distributed, and then pass it through the sieve. A little experience will give a better idea of how damp the sand should be than can be expressed in words. It should be just sufficiently damp to hold together, but not to feel at all wet.

To make the mould, set the cast on the bench with the back toward you and its face uppermost; place over it the flask, so that it occupies a central position. Now take up a handful of sand and sift it through the fingers on the cast, making it as fine as possible by rubbing it between the hands until the cast is entirely covered; then with the fingers press it down firmly, packing it especially well between the sides of the flask and the cast. I prefer the fingers for this purpose to avoid any injury to the cast. After the cast is covered the sand may be added more rapidly until the flask is full. Press the sand down firmly and evenly, but not too solidly. If it is not packed firmly enough, the mould will be rough, the cast inclined to drag, and the sand liable to be displaced when the metal is poured in; if it is packed too solidly, there is danger of the die being injured by bubbling of the metal. The sand should be somewhat porous to allow

one, which may then be parted by removing the long pin, and the model taken away. When closed and the two put together again and inverted, it is ready to receive the melted metal (*Dental News Letter*, vol. iv. p. 58).

the vapor caused by the hot metal to escape quickly. The desirable mean between these two extremes can only be learned by experience.

When the flask is full, level off the surface with the wooden rule previously mentioned, and, lifting the flask and its contents, brush away the sand from that part of the bench, and, turning the flask over, carefully lay it down with the bottom of the cast up. Next run the point, held at an angle of about 40°, all round the cast, so as to make a bevel in the sand one-fourth of an inch deep and from one-fourth to one-half an inch wide. Brush off the sand the point has loosened, or the flask may be raised and the sand thrown off by a quick motion, care being taken that the cast is not disturbed. Now with the fingers press the sand firmly all around the cast, and see that there are no loose particles to fall into the mould as the cast is removed. Then take the wooden rule, and, resting one end of it against the edge of the cast, say at the front, having the other slightly raised, gently tap it with a small hammer or mallet; repeat this at the back, and then at the sides; then give the bottom of the cast a few taps, evenly distributed. These taps should be very gentle; they should not move the cast: the object is to jar the cast so that it will readily part from the sand. Now take the point in the left hand, and, resting the wrist firmly, place the point about the centre of the cast, and with the hammer gently tap it so that it will be driven slightly into the plaster cast, and thus make a handle with which to lift it from the sand. It need enter but very little to hold firmly enough for this purpose. Now carefully raise the cast a very little, at the same time gently tapping the end of the point; if it does not readily leave the sand, let it fall back, and endeavor to humor it as it is slowly raised, so that it will leave the sand in the direction of least resistance. These manipulations must be gentle, or the cast may be tilted or rocked in the sand and thus make a false impression. In tapping with the mallet there is danger of doing this, and so making a die with the ridge too high, so that a plate fitted to it, failing to meet the alveolar ridge, would press on the centre of the mouth; or, again, if too much force is used the cast may be driven down bodily; then the die would produce a plate fitting very well everywhere except outside the alveolar ridge. These mishaps are liable to occur, but never do if care and judgment are used; they are the reward of carelessness.[1]

This tapping assists very much in removing the cast without disturbing the sand; and also in cases where the sand is broken from the mould and held in an undercut it is frequently jarred out and falls

[1] I notice that, as a rule, the books direct that the cast be allowed to fall from the mould, and that either the cast or the flask be gently tapped while held in a suitable position, so as to cause it to do so. I have always made it a rule to lift the cast from the mould in the manner described, and invariably have rejected a mould from which the cast has fallen out when the flask was raised, for the following reasons: There is usually at some part of the cast a point where the sand tends to hold it in position, frequently about the middle or at the condyles. When the cast falls out by its own weight, the slight resistance at this point tends to form a pivot on which the cast momentarily turns, and in doing so strikes and slightly displaces the sand. The effect may be very slight, but still sufficient to make a more or less serious rock in the plate. Sometimes it may be held at one side with the result of making a side rock or spring. I have repeatedly found this to be the case.

back into its place, where it may be secured by a drop of water or a slight pressure with the point. Moulds which have had a portion of the sand broken and replaced in this way require extra care in pouring, so that a redisplacement may not occur. Instead of filling the mould at once, pour in enough metal to nearly cover the fractured portion, and then stop a moment to let the metal approach the setting-point; then pour in a little more, just to cover it, and in a few moments complete the operation. By this care the metal hardens sufficiently to hold the sand in place, but not so much as to make a seam in the die; that is to be guarded against. If the metal is poured in quickly, the broken portions will probably be floated up and the die be a failure. In these weak moulds the danger is not only from the force of the stream of metal, but also from the greater lightness of the sand, which renders it apt to float from its position if covered with molten metal to any depth. There is no advantage in these cases in pouring the metal after it has begun to thicken: while not too hot, it should be hot enough to be quite fluid; the stream of metal then flows into the mould gently and evenly.

In difficult cases, before beginning to make the mould carefully examine the cast and note those portions that are likely to drag. Turn it upside down, hold it in the position it will occupy when you begin to remove it from the sand, and notice as you raise it what changes of direction will be likely to disturb the sand the least. In removing upper casts where the alveolar ridge overhangs we often get a better impression by slightly raising the back part of the cast first—that is, tilting it—but at the same time being careful not to press the front down deeper into the sand; then draw it toward you as it is slowly raised; and in lower casts where the alveolar ridge is quite thin and leans in, this operation may be reversed. Again, in these cases it is sometimes best when the cast is placed on the moulding-bench to tilt it up by putting sand under the front, or, what is better, after the flask is in position to remove the cast, to tilt that up so as to bring the cast into the position it would have occupied had it been tilted. It is very important that the die should be level: if the cast is tilted, then to produce a level die the flask must be tilted to the same degree in a reverse direction before pouring. If the flask is tilted, after the cast is removed I simply place it in its original position, thus getting all the advantage of tilting the cast without its risk. In some cases, especially partial ones, it is necessary to tilt to either side on account of leaning teeth, etc. It is impossible to give directions that shall meet all cases: these suggestions will perhaps give an idea how such difficulties are to be met, and may suggest other means of overcoming them.

Having removed the cast, examine and see if any sand clings to it on those portions included within the line of the plate; if there is, before disturbing it examine the mould; if that is not badly broken up, lay the cast aside. Then with the fingers carefully press the loose sand around the mould, rounding the bevel made with the point; in doing so be careful that no sand falls in. When this is done the flask may be lifted up, if it can in that way be more conveniently examined. Notice its condition: it may be that at some point the sand may have been

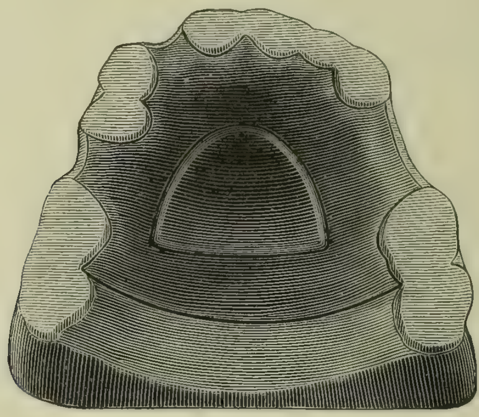
broken, but still not be so badly displaced but that it can be restored. If so, with the point move it into position, and then with a camel's-hair pencil or the point let a drop of water fall on the line of fracture. This will hold the piece in place, and in many cases avoid the use of cores. With care the sand drawn out with the cast may sometimes be removed and returned to the mould. We may often with advantage add sand to places where it has been drawn out with the cast. By these expedients we may save a great deal of time and trouble, and secure as accurate results as by any other means. In all of these cases it will not do to turn the mould upside down to get rid of the sand that may have fallen in; we may blow it out with the glass tube, or lift it out by moistening the end of the tube or the point and touching the sand, which will then adhere to it.

Having obtained a satisfactory mould, we now proceed to pour it, as the technical phrase is. Zinc is generally used for this purpose. It is best to put the zinc on the fire when beginning to make the mould, and so arrange that it will be melted when the mould is ready. Arrange the moulds on the bench so that they can be conveniently reached; avoid having them too close together. Select for each a casting-ring about the same size as the base of the cast, and lay it within convenient reach. Now, having the zinc melted, but not too hot, bring it to the bench: with an iron spoon or other suitable implement remove the oxide or dross from the surface of the metal near the lip of the melting-pot, so that it will not pass into the mould, and, holding the pot as close to the sand as possible not to touch or disturb it, begin to pour a gentle stream of metal at the back part of the mould, and continue without stopping until the mould is nearly full; now place the casting-ring in position, add a little sand all round on the outside, pressing it well down, and then pour in sufficient metal to make the die thick enough. The casting-ring is used to make the zinc die thicker than the plaster cast. The cast could of course be made thick and the ring be dispensed with, but to do so would make it clumsy and inconvenient to work with, and the mould being so deep would prove a serious disadvantage in many cases. If bubbling should occur, stop pouring immediately, and watch until the metal begins to thicken slightly; then pour in a little more, holding the ladle eight or ten inches above the mould. If it does not recur in a few moments, complete the operation. If it continues, add the metal a little at a time. The "jarring" caused by the metal falling from a distance will often so displace the vapor that a fairly good die may be obtained; but, as before remarked, where bubbling has taken place the die cannot be relied upon. After pouring remove the metal that usually overhangs the lip of the pot, and, before setting it aside, pick up and return to the pot any metal that may have been spilled. When the zinc is fully set—and it is best to give it plenty of time—turn it out of the mould. Examine if it needs any trimming before making the counter-die; if it does, and there is much metal to be removed, it may be roughly cut away with a cold-chisel while the zinc is hot, the zinc being more readily cut while in that condition; but where accuracy is required it must first be cooled off by placing it in water. If it does not need trimming, it may be immediately banked up to make the

counter-die. To do this, place it, face up, in a flask large enough to leave at least half an inch of space all round, letting it stand above the edge of the flask as far as it is desired that the lead counter-die shall cover it, and pack in sand to within one-fourth of an inch of the line of the plate, or in partial cases to about the line where the gum joins the teeth; make the surface smooth and place over it a casting-ring about half an inch larger, all around, than the face of the die. When the lead is melted (lead is generally used for making counter-dies) carry the ladle to the bench, and let it rest until a piece of lead dropped into the molten mass does not fuse. As soon as it has cooled to this point pour immediately, making the counter-die about half an inch thick over the most prominent part of the die. If the lead is too hot, and especially if the zinc also is hot, there is danger of their uniting; but if the rule given above is observed there is not the slightest risk. Observe the same precautions recommended after pouring the zinc, of removing the metal from the lip of the melting-pot, etc.

Should the zinc die not be quite level, make it so by placing sand under it when preparing it for the counter-die. When the lead has set remove it from the flask, brush off the adhering sand, and if wanted

FIG. 342.

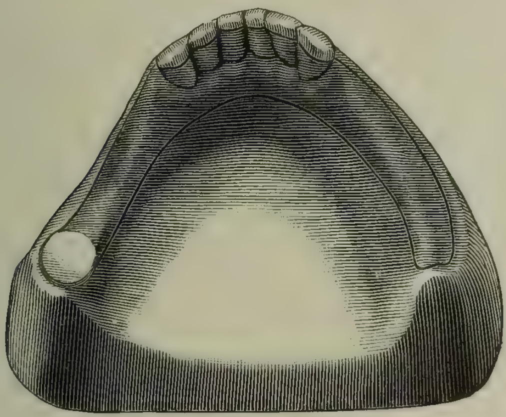


immediately cool in water. In using zinc and lead it makes no difference whether they are cooled rapidly or not—it is merely a matter of convenience—but with some of the alloys more careful treatment is required. It is usual—indeed necessary—to make two sets of dies for swaging metallic plates, and in order that the die and counter-die made together may be readily known, they should be plainly marked before being separated. To separate them hold them in the hand, the hand resting against the knee, and strike the back part of the zinc die with a hammer. In some cases, with a very thin prominent ridge or to avoid breaking the teeth in partial cases, it may be best to tap it all round and "coax" them apart by a gradual enlargement of the counter-die.

Generally, the dies will now need a little trimming where the sand may have dragged, or where wax has been used to reduce an undercut

or to remove an accidental roughness. Unless the defect is marked it may be left until the counter-die is made. After they are separated examine both sets, and select the best for the finishing die; bestow extra care in making it as accurate as possible. If they are for a partial upper plate, cut all the teeth from the die that is to be first used with a hack-saw or chisel, leaving only enough to make an imprint in the plate as a guide in filing it to fit around the teeth, as shown in Fig. 342. File off also all sharp or abrupt points that do not belong to the face of the die, and so shape them that they will not be liable to tear the plate while swaging it. In partial lower cases the plate is usually allowed to rest against the teeth; in such cases file the teeth down to within about a sixteenth of an inch of the line of the plate, and slope them toward the outside, as shown in Fig. 343, so that the

Fig. 343.



edge of the plate will hook over, and the tendency to strike down when first working the plate into place be overcome. In all cases let the finishing die be as nearly a perfect duplicate of the cast as possible; do not cut the teeth from it or do anything that will mar or injure its face.

A good set of dies is absolutely essential to produce a well-fitting plate: a defect in the dies cannot be remedied by any after-manipulation.

ARTIFICIAL DENTURES ON BASES OF GOLD AND SILVER.

By WILLIAM H. TRUEMAN, D. D. S.

Suggestions Regarding the Laboratory, its Fixtures and Tools, with Special Application to Plate Work.

In a dental laboratory light and ventilation are of the utmost importance. Although an operator who does his own mechanical work may spend in it but a few hours a day, they are usually made up of spare moments that would otherwise be devoted to much-needed rest, and should therefore be made as much as possible a relaxation and not a continuation of the labors of the chair. Laboratory manipulations conducted in a close, crowded, poorly-ventilated room, selected solely because it is undesirable for other uses and can on that account be better spared, are not conducive to the operator's health, while a few hours so spent in a well-appointed workroom, at an employment so different from that of the office, and which brings into active use muscles comparatively inactive at the dental chair, may prove a pleasant recreation and a rest. It may at the same time enable him to accomplish with his own hands operations that could not be satisfactorily explained to an assistant, however skilful. The progressive dentist usually makes the laboratory a study as well as a workshop. It is here, surrounded by the conveniences it affords, that most of his microscopic work is done and chemical and other investigations are conducted. It thus becomes important that its conveniences and healthfulness should be carefully considered.

The character and amount of work likely to be done in the laboratory will largely determine its furnishing. If for the sole use of a dentist whose practice is largely operative, many conveniences may be omitted, and fewer and less expensive tools provided than would be necessary to meet the requirements of a workman who makes mechanical dentistry a business. We would suggest, however, that it is unprofitable economy to attempt to "make out" with a poor or incomplete selection. Many time- and labor-saving devices used by the dental mechanic would no doubt be more frequently seen in private laboratories if their usefulness were known and appreciated.

The workbench is the most important and indispensable fixture in the laboratory. The dental mechanic will usually occupy this exclusively with the hand tools, while in a private laboratory it may be made to accommodate in addition the grinding-lathe, blowpipe, etc. It is better to keep from it all operations requiring agents that are liable to

rust or injure the tools or to contaminate the precious metals, and, whenever it can be done, to provide for these operations a separate table or bench. The workbench should be solidly constructed, the top being formed of hard wood at least two inches thick. Firmness and solidity are quite important in many delicate operations. Its shape will be determined by the position it is to occupy; where room is an object a square bench will be the most compact: this when placed against a wall will accommodate three workmen, the tools, etc. being equally accessible to each. A pin or block projecting two or three inches should be firmly morticed into the edge of the bench opposite the position to be occupied by the workman, its upper surface level with the top of the bench, its projecting end bevelled off at an angle of about 60°; this forms a rest for the hands or the work. Underneath this should be two shallow drawers lined with tin-plate or sheet zinc—one for gold, the other for silver—so arranged that either may be drawn out without interfering with the other. These are to catch the scraps and filings. When in use the outer edge rests in the workman's lap, so as to be out of the way. It is a very common but very objectionable practice to make these drawers also receptacles for tools. Apart from the fact that tools so disposed are out of sight when the drawer is closed, and on this account liable to cause an annoying loss of time in searching for them when they are needed, there is also a loss of the precious metals, owing to small particles adhering to the handles, or quite large pieces may be jarred from the drawers when the tools are carelessly dropped in.

A large vise, with jaws three or four inches wide, should be firmly fixed to the bench. In it the metallic dies are held while forming the plate upon them preparatory to swaging. The smaller bench-tools should be arranged in a rack at the back of the bench. "A place for each and each in its place" is an excellent rule. The tools usually associated with the bench are as follows:

A small anvil set in lead. This is made to resemble in shape the large anvils used by blacksmiths: it should be provided with a groove across the face for forging wire, and the sides should slope at various angles for convenience of bending excavators, etc.

Burnishers of several shapes made of steel, agate, or bloodstone.

A bench-brush made of fine bristles, used to sweep the filings, etc. into the drawers.

An iron saw and a cold-chisel for cutting teeth from zinc dies and roughly trimming them.

A pair of clasp-benders.

A selection of files: those in general use are half round, moderately fine cut, five or six inches long. In addition there will be needed one of the same size and shape "dead smooth," a small round, and a small flat file, and one half round, of coarser cut, eight or ten inches long, for use upon the metallic dies.

A jeweller's saw-frame and saws.

A plate gauge (the American wire gauge is now generally used).

A selection of gravers, round and flat.

A bench hammer, weighing about two ounces, the blade at right angle to the handle, the head well rounded, smooth, and hard.

A mallet of either wood or horn.
A lead-pencil.
Plate-shears, straight and curved.
Plate-punch or nippers.
Plate-benders.
Punch for rivet holes.

Pliers, round and flat nosed. One pair of flat-nosed pliers should have quite narrow beaks; another, for holding backings while filing them into shape, should be large and strong, so as to grasp them firmly; a pair with one beak rounded and the other flat is at times useful, but not necessary; a pair of gas-fitter's pliers, medium size, will be found extremely useful for various purposes.

A steel and a bone chaser for forming swaged vacuum-cavities and other like purposes; the latter may be made from a toothbrush handle.

A pair of scissors; a scraper: the triangular form (see Fig. 386) is most useful for plate work, and may be made from a small worn-out three-sided file; a wet stone for sharpening tools, either Washita or Arkansas; a wax spatula; a pair of tweezers; a number of points made from broken excavators, used to pick the wax from invested cases preparatory to making the backings and for reaming rivet holes, etc.

The workbench should also be provided with a heating apparatus for softening wax, manipulating the rosin-and-wax cement, waxing up cases, etc.: an alcohol lamp, or, where gas is available, a small Bunsen burner will do all that is required.

It is recommended by some to have attached to the workbench the grinding-lathe. This I consider objectionable on account of the water used with the corundum wheels; I much prefer to have it on a portable stand. Formerly in this process a turning-lathe with suitable fittings was universally used; within the last few years a number of different patterns of polishing-lathes have been introduced, to meet the needs of electro-platers and others whose work embraces the operations of grinding and polishing, that are far preferable in every way. I think it is better to have a light, easy-running lathe for grinding, and another, stronger and larger, for polishing. Machinists supply suitable machines, well made and at so reasonable a price that two may be now had for less outlay than was formerly required to purchase one. The grinding-lathe should be provided with means to keep the corundum wheels constantly wet; thus used, they not only last much longer, but cut much more rapidly. It should also be provided with a drawer or other receptacle in which the rosin cement used for attaching teeth to the plate is kept, and a suitable heating arrangement for manipulating the same. The working parts of both the grinding- and polishing-lathes should be closely covered at all times to protect them from the gritty particles with which they are constantly surrounded. The operation of polishing is rendered far more cleanly by surrounding the polishing wheels with a hood, so arranged that while it catches and retains the polishing material thrown from the rapidly-revolving wheels, it does not obstruct the view or interfere with the necessary manipulation of the case. The

polishing-lathe should be accompanied with suitable receptacles for the polishing powders, and a rack or other device to hold the felt and brush wheels, etc. used with it. The workbench and grinding-lathe should have the best light the room affords.

A table or bench for manipulating plaster should be used exclusively for that work. It should be so arranged that the waste may be kept from the floor and passed through a hole in the bench to a receptacle beneath. It may be provided with boxes to hold plaster and the sand and the asbestos used in investing. A large knife, hinged at one end, will be found useful for roughly trimming casts ; a smaller one for hand use, a water-pitcher, bowls or saucers, and a spatula for mixing plaster, are all that is needed on the bench.

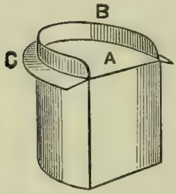
On a shelf within convenient reach locate the varnish for casts, the varnish or other parting preparation for impressions, and a number of pieces of glass of various sizes, upon which investments are placed and casts and articulating models moulded to prevent them adhering to the bench and to give them a smooth surface. Broken window-glass answers the purpose nicely.

The moulding-bench also should be exclusively used for that purpose, and should be provided with flasks, tongs, sieve, and other tools used in making metallic dies and counter-dies. It should also have a series of shelves for the new and old dies, the melting-pots, and the lead, zinc, and other metals used.

The blowpipe also I prefer to place upon a small table by itself; many, however, place it upon the workbench, which can be conveniently done with the small, compact, and yet effective arrangements now attainable. To produce a continuous blast, a pump constructed entirely of metal, compressing the atmospheric air into a small cylinder, is far more durable and satisfactory than any form of bellows we have seen. Several forms are now offered by dealers in machinery. The blowpipe has been greatly improved of late years, especially that designed for use with gas. One I have used for many years is attached to the bench by a ball-and-socket joint, readily moved in any direction and self-retentive in all positions. The gas-jet used with it is a Bunsen burner placed in a horizontal position and hinged so as to move horizontally. There are several in the market that are favorably spoken of by those who have used them, in which the gas and the air of the blast are commingled in the blowpipe itself just before combustion ; the apparatus is held in the hand, the air and the gas being conducted to it through flexible rubber tubes, the supply of each being regulated by cocks so placed that they may be controlled by the fingers of the same hand that holds the blowpipe. This form has been so perfected that it may be obtained "self-lighting," an automatic valve closing when it is hung up after use, so as to nearly cut off the gas-supply, leaving only a very small flame, which recedes into the body of the instrument so as to be protected from drafts, etc. : when the blowpipe is lifted from its support, this valve opens, permitting the passage of a full supply of gas, which is immediately ignited. In this blowpipe the work remains stationary, the blowpipe being moved so as to direct the flame against the work ; the operator is thereby relieved of the strain of holding the soldering

support and the invested work. For holding the work to be soldered I prefer a sheet-iron case, shown in Fig. 344. A piece of the fireclay slab upon which artificial teeth are baked is fitted into it near the top, forming a level surface, A, upon which the work rests; the projecting portion, B, prevents it from sliding off; the ledge C protects the hand in case the flame should be accidentally directed toward it, as may frequently happen; the space between this and the bottom of the support is filled with some light non-conducting substance—for instance, asbestos or mineral wool—this being kept in place by a coating of plaster of Paris. An arrangement of this kind will last for years. Near to the blowpipe may be kept the solder, borax plate, a pair of long tweezers for handling the work, a pair of solder-tongs, a steel wire about one-eighth inch thick and six or eight inches long set in a wooden handle, the end pointed: this is used to correct the position of the solder and to direct it as it flows. Where gas is obtainable it makes by far the most convenient and effective flame. Mr. Thomas Fletcher of Warrington, England, has devised an apparatus for using a light benzine, gasoline, or other easily-vaporized hydrocarbon for this purpose, and also for use with the gas furnace he has introduced. It consists of a metallic box in which are suspended a number of diaphragms of loosely-woven cotton cloth, the ends resting upon the bottom of the box. Sufficient benzine or gasoline is poured in to form a layer about one inch in depth; this is taken up by the diaphragms, thereby exposing a large surface of the vaporizable fluid. The air-blast of the blowpipe is divided, a portion passing through the box, where it becomes highly charged with the gasoline vapor, and when ignited produces a pure and intense flame. This apparatus may prove a convenience where gas cannot be obtained, but it must be remembered that benzine or gasoline is an exceedingly dangerous compound. It vaporizes at a very low temperature, its vapor is heavier than the atmosphere, and when mixed with it becomes highly explosive. It has so frequently caused serious accidents that I consider it unsafe, no matter how carefully the apparatus it is used with may be constructed. In the absence of gas an oil or alcohol lamp specially constructed for blowpipe use is far preferable when safety is considered.

Fig. 344.



Soldering Support.

For swaging plates an anvil weighing not less than twenty to thirty pounds is required. To deaden the noise and prevent vibrations it may be set upon soft rubber blocks or upon a bed of cork cuttings or any similar elastic body. One with a face about four inches square is rather more convenient than the usual shape used by blacksmiths. The swaging hammer should weigh about six pounds.

Chemical operations giving off acid or other unpleasant fumes should be conducted in a closet with an opening to the external atmosphere or connected with a flue having a strong draft. In such a closet, provided with suitable heating arrangements and a glass door through which the operation may be watched, the various processes of refining the precious metals may be conducted; in it should also be placed the vessel con-

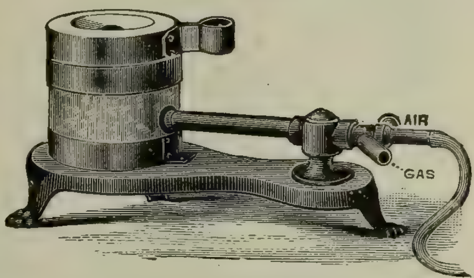
taining the acid "pickle" used to cleanse the case after soldering. In constructing the closet all the wood used should be thoroughly saturated with paraffin on the side exposed to the acid fumes. This is easily done by first coating the thoroughly dry wood with paraffin, then passing over it with a hot iron until the wood has absorbed all that it will; the surplus may be wiped off with a cloth. Thus treated, it resists the destructive action of the acid remarkably well.

A rolling-mill is almost indispensable, and, expensive as it is, will soon pay for itself in the saving of time and material. It should be at least single-geared; without gearing the rolls do not always move in harmony; this in rolling will make a narrow strip uneven in thickness. The double-gearing, while adding materially to the cost, makes it far easier and more convenient to use. When not in use the rolls should be carefully covered, their surfaces slightly coated with cosmoline to prevent their being marred by dirt, rust, etc.

There should also be provided a free water-supply, located, if possible, near the acid-closet, with conveniences for getting rid of the waste.

For melting the metals used for dies and the precious metals an ordinary cylinder stove used for heating purposes may be used, or a small-sized kitchen range of the pattern known to builders as a "gas oven," built in with brick-work, is more effective on account of the draft being more direct, and has the additional advantage during the warm season of not heating the room. With either, the various operations of melting or heating cases for soldering may be conveniently conducted. Where a furnace is seldom required and the laboratory is supplied with gas, there are on the market a variety of gas stoves giving sufficient heat for melting the metals used for dies or preparing cases for soldering. For melting the precious metals, making solder, etc., Mr. Fletcher has invented several crucible furnaces using gas as fuel; some of these are self-acting, others require a forced blast. That shown in Fig. 345, I have found very useful; in it several ounces of gold may be fused in from eight to ten minutes; it is always ready for use, and in case of accident to the crucible the metal spilled is received upon a clean surface, where it is easily recovered without loss. These furnaces are also made to burn refined petroleum or kerosene. For fusing small quantities Mr. Fletcher provides an apparatus consisting of a gas blowpipe, a flat plumbago crucible, and an ingot-mould combined (shown in Fig. 346). The metal to be melted is placed in the crucible; the blowpipe, which is so fixed as to direct the flame upon it, and also to heat the ingot-mould, is operated until it is perfectly fused, when the apparatus is tilted over, causing the metal to flow into the ingot-mould. With this arrangement an ounce or two of gold may be made into an

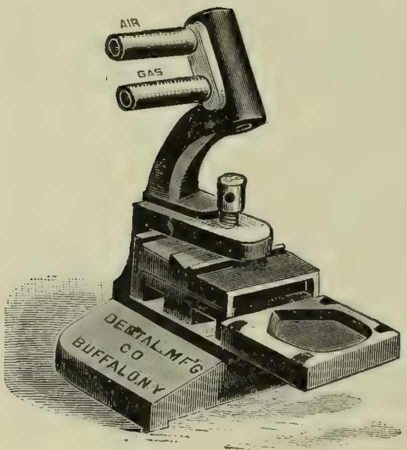
FIG. 345.



Fletcher's Gas Furnace.

ingot in a few minutes. Mr. Fletcher has made the improvement of heating apparatus for using gaseous fuel a special study for many years. A number of his devices are especially useful in the laboratory for heating cases for soldering, etc.

FIG. 346.



Fletcher's Melting Arrangement.

A portable forge, provided with a blower and connected with a flue, will be found useful where gas cannot be obtained.

A series of narrow shelves may be set apart for the casts, properly numbered and indexed, of finished cases; they are frequently needed in cases of repair.

Suitable closets, boxes, and drawers are needed for the various articles in constant use—the stock of teeth, plaster, polishing material, wax, etc.

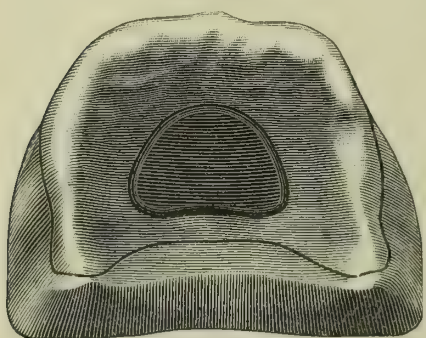
A pair of scales and a set of troy weights are indispensable. The scales should be sufficiently delicate to turn with the fraction of a grain, and should be kept where they will be protected from dust and dirt.

Cleanliness and order are of first importance in a dental laboratory; a few tools sharp and in good working order are far better than a large collection carelessly kept.

MARKING THE PLATE-LINE.

The first step in making an artificial denture is to accurately mark on the cast the outline of the intended plate. This calls for care and judgment. In a full plate we must first decide whether the teeth in front are to rest on the plate or on the gum; and in a partial plate, whether it is to be retained in place by clasps or by suction.

FIG. 347.



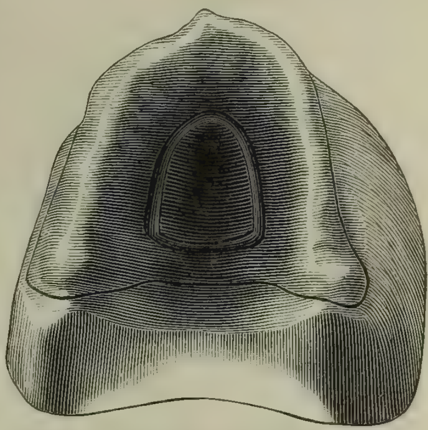
Position, Relative Size and Shape of Vacuum-cavity for broad palatal arch.

In full upper plates begin to mark the outline at the back part of the cast, being careful that the plate-line does not encroach upon the soft palate, curving it in to avoid this, and extending it to well cover the condyles; let it go up as high as it can on the outside without interfering with the muscles and reflected portions of the mucous membrane of the lips and cheeks; as it comes forward allow room for the fræna on either side and in front of the mouth. It

is best to carry the plate up on the outside of the ridge as far as it can be borne with comfort: this not only gives a better suction, but prevents food getting under the plate. If it is found too high it can be readily cut away at any time.

Next mark the position of the vacuum-chamber or suction-cavity. It is best not to let it extend far over the rugæ, and to allow at least one-eighth of an inch between the chamber and the back edge of the plate; more than this is desirable. In shape it should conform somewhat to the general contour of the palatal arch. If this is broad, Fig. 347 would probably be more suitable, while a long, narrow arch would require a chamber shaped like Fig. 348. In some peculiarly shaped mouths it may be made round or oval: avoid all fanciful shapes, such as shields, stars, etc.; they are entirely out of place, and the sharp corners and recesses are a frequent source of irritation. In size let it be about one-fourth the area of the space enclosed by a line around the centre of the ridge and the back of the plate; this is only an approximate rule, but a good one. If a plate has been worn before, it is better to let the chamber remain in the same place as its predecessor, and make it just a line larger all round; on this account the first plate that is made for a mouth should have the chamber rather small. If the chamber should be so far out of the desired position that a change is necessary, either let the patient lay the old plate aside for a week or two or fill up the chamber with gutta-percha, and let the case be worn in this condition until the impression the chamber has made on the roof of the mouth has nearly if not quite disappeared. Unless this precaution is taken, there is usually trouble in getting a satisfactory suction.

FIG. 348.



Position, Relative Size, and Shape of Vacuum-cavity for narrow palatal arch.

If the gum is very full in front, so that the teeth must set directly upon it, the front line of the plate should be so made as to permit this, but always allow it to come as far over the ridge as possible; make the plate a little large, and file it away as required when arranging the teeth. As a rule, I find in these cases that the plate is cut away too much, and does not come under the teeth as far as it should, this defect being especially noticeable when plain teeth are used. In arranging plain teeth on a full upper case the plate should be well bevelled, and be allowed to come so far forward that the teeth only just cover it; the plate should not be cut away between the teeth until the case is soldered. It is so difficult to know exactly where the teeth will come until they are arranged in position that it is always best to have the plate amply large. If it is made too small, either the teeth will be without proper support

or the plate must be extended by soldering a piece to it; the latter is by far the least objectionable plan, but is apt to give subsequent trouble in soldering the teeth and finishing the case, unless the added piece is soldered with very hard-flowing solder. This rule applies in all cases, partial or full plates, in the upper or lower jaw, and has no exception if a neat piece of work is desired.

In full lower plates the same general rule for marking the plate-line holds good: allow the plate to extend as far over the ridge on the outside as the integument will allow, giving ample room for the fræna; inside there is usually found a groove or depression, more or less marked, extending around the front, in which the edge of the plate may be allowed to rest; the back part of the plate should just cover the curve of the gum, so that the edge will be out of the way of the tongue. It should not be made too wide; if it is, although it may be comfortable when at rest, it will, on account of a slight side movement during mastication, which is in most cases unavoidable, press into the cheek or into the gum, or it may irritate the tongue. There is danger of extending the plate too far back, and not to extend it far enough may cause equal discomfort; this is a matter for observation and judgment. In some lower jaws the muscular attachments are far up on the ridge; sometimes when this is the case, if the plate is allowed to press upon them, they will after a time be pushed down and the plate be tolerated; in other cases the plate must be made very narrow to avoid them, or it will be thrown out of place by the movements of the muscles of the mouth and tongue; these cases are frequently quite difficult to manage.

Great care and judgment are called for in arranging the outlines of partial plates: the peculiarities of such cases are so numerous that it is impossible to give any but very general directions. Partial upper plates retained by suction—indeed, all partial upper plates—should fit around the remaining natural teeth snugly. If the plate rests upon them, the suction is impaired; if there is any perceptible space, the mucous membrane is apt to be forced down into it, and soon becomes sore and painful. It has been recommended to make the line of the plate about one-eighth of an inch inside the line of the teeth, conforming to the general outline, but not fitting into the interspaces between them. As a rule, this is not to be commended, as it brings the front edge of the plate into a position where it is more perceptible to the tongue, and deprives the plate of a degree of stability given to it by the plate fitting closely between the teeth, side motion being thus prevented. There may be cases where plates made in this way are more comfortable, and occasionally they require to be so made to avoid the lower teeth. The size of plate is regulated by the number and position of the teeth to be supported and the general contour of the mouth. As a rule, make the plate as small as possible to be firmly sustained, and take advantage of any depression that may be in the roof of the mouth in which the edge of the plate may rest and be less in the way of the tongue. A plate supporting any teeth anterior to the molars may end at the interspace between the second bicuspid and the first molar or the middle of the first molar of each side. It is better to well round off the corners, forming the outline of the posterior edge of the plate in graceful curves,

as shown at A, A, A, Fig. 349, and avoid the triangular points B, B, which while adding nothing to the usefulness of the plate are so easily bent. Avoid, rigidly, all fanciful forms; they are entirely out of place.

Where only one tooth is to be supported, it has been suggested to make partial suction-plates quite small, about half an inch square, or where there is one tooth on each side to make a small plate for each, and connect them with a band. I have found no advantage in this. The vacuum-chamber is nearly as large as the plate, leaving very little bearing surface to take the pressure of mastication. The band, if made heavy, is very much in the way, and if made thin is constantly bending. Such plates are seldom satisfactory.

Fig. 349.

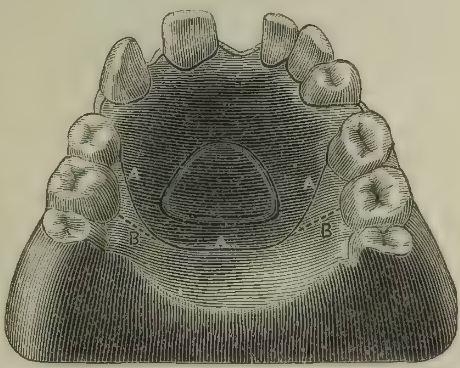


Plate-line for Partial Denture retained by suction.

Partial plates to be supported by clasps or bands are usually made narrow, and frequently the posterior line may be drawn almost entirely in the depression of the rugæ, thus placing it where it is least in the way of the tongue. These plates are often made too small. It must be remembered that unless there is sufficient bearing surface the pressure of mastication will press them painfully into the roof of the mouth. And, again, we see that an effort is sometimes made to retain plates with

Fig. 350.

Plate-line for Partial Lower Denture supplying posterior teeth.

but slight attachment to the natural teeth, under the impression that the teeth are thus saved from injury. This is often a mistake: an extra clasp will frequently hold a plate more firmly, and, while making it more comfortable for the patient, will lessen the strain and wear upon the teeth to which it is attached.

Partial lower plates are made to extend up over the lingual surfaces

of the remaining natural teeth, and are not cut out to fit around them, as is the case with upper plates. There are two reasons for this: First, the bearing surface of a lower plate, on account of the narrowness of the alveolar ridge, is necessarily of small area, while the pressure of mastication is quite as great as that borne by the upper plate; therefore it is desirable to let the plate rest against the natural teeth to prevent it from being pressed painfully against the gums; and secondly, where the plate passes inside of the teeth, either connecting the two sides of a denture supporting the posterior teeth, the anterior natural teeth being in place, as in Fig. 350, or where, this being reversed, as in Fig. 351, it extends at the sides from the replaced teeth to the clasps, or as in Fig. 352 to support teeth anterior and posterior to the remaining natural teeth, it would, if it did not extend up beyond the gums, be so narrow as to require being made excessively thick to secure the necesssary strength. Where it is extended upon the teeth and swaged to fit accurately between them, we have not only added strength on account of the increased width of the plate, but the peculiar shape of these parts imparts to it a marked degree of stiffness. When the plate passes inside of the anterior teeth its upper edge should be just above the rounded portion

Fig. 351.

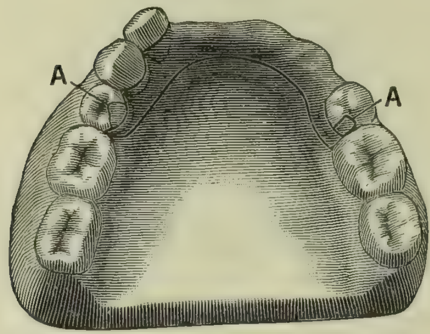


Plate-line for Partial Lower Denture supplying anterior teeth.

Fig. 352.

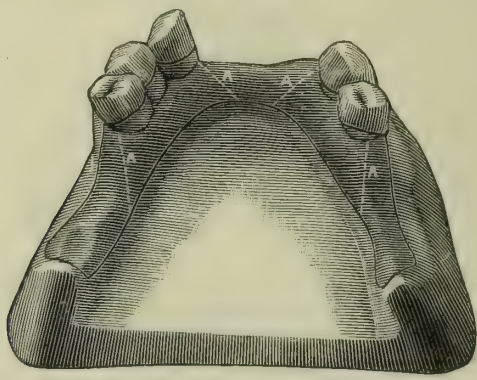
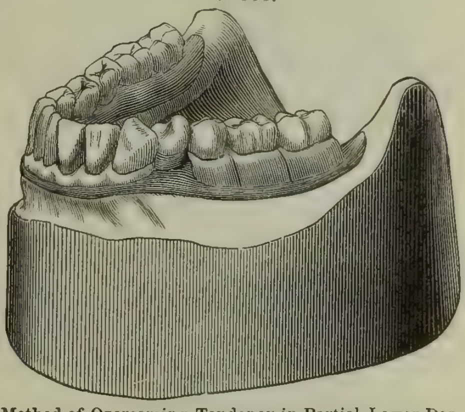


Plate-line for Partial Lower Denture supplying anterior and posterior teeth.

of the teeth (A, Fig. 350), and rest upon the broad flat surface approaching the cutting edge, as shown at B in Fig. 350. This allows the plate to rest closely against the teeth, and when the edge is neatly rounded is far less perceptible to the tongue than it would be if it terminated lower down where the interspaces are wider. The lower front edge should be so far down that the tip of the tongue will not be liable to

get under it, and yet not so far down as to press upon the frænum of the tongue. The posterior portion of a partial lower plate may follow closely that portion of a full plate, as already described. When the denture supports the anterior teeth the front line will follow very nearly that portion of a full plate; as it proceeds backward the upper edge should rest against the natural teeth, as shown in Fig. 351. This will give a general idea. There are many complications in lower partial cases, owing to the position of the missing teeth and the position of the teeth that remain, and much thought is required to arrange, and a great deal of skill to construct, accurately fitting dentures. The following plan has been suggested by Dr. Essig:[1] "Having to make a partial lower plate sustaining the posterior teeth, the incisors, cuspids, and the first bicuspids being in position, for a mouth so shaped that it could not be expected to remain in its place without clasps, there being a decided tendency in the plate to slide back, and to arrange clasps in the usual way being impossible, owing to the leaning position of the two remaining bicuspids, and none of the other teeth being available, it was successfully treated by continuing a narrow portion of the plate entirely around the front of the arch, resting upon the gum just below the teeth. This piece I made of two thicknesses of gold carefully swaged to fit accurately, and against the buccal surfaces of the bicuspids a piece of gold, semilunar in shape, was attached to the adjunct piece, as shown by Fig. 353, thus preventing any undue pressure upon the gum in front, and at the same time holding the case firmly in place during mastication."

Fig. 353.



Method of Overcoming Tendency in Partial Lower Denture to slide back.

The subject of selecting the teeth to be clasped naturally presents itself at this time, as the size and form of the plate largely depend upon the teeth chosen; and in practice the position and character of the clasps are always marked upon the cast at the same time as are the outlines of the plate.

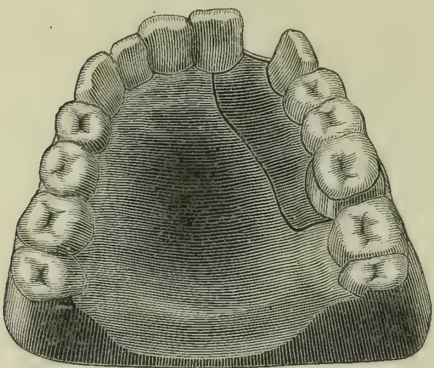
Locating the clasps is often left to the workman's judgment: this I consider a serious error. He may judge of their shape and of their position relative to the teeth to be replaced, and perhaps correctly consider the mechanical principles involved; but no one but the operator who takes the impression and adjusts the case in the mouth can form an idea of their relative fitness for the purpose. The usual rules laid down look only to their relative firmness and to the ease with which the clasps can be adjusted so as to give the greatest degree of support with the least exposure. This was enough a few years ago, but now, when the preservation of the natural teeth is receiving so large a share

[1] See *Dental Cosmos*, vol. xvii. (1875), p. 148.

of attention and with such marked success, we are prone to use for this purpose, at times, teeth which formerly would have been rejected without a moment's hesitancy. I have known artificial crowns to be inserted for the sole purpose of using them to support a clasped plate, and gold crowns to be adapted to roots, and teeth extensively decayed to be restored by filling with the same end in view, simply that these teeth might take the wear and tear incident to clasps, and thus save other and more valuable teeth that a few years ago would have been considered far more suitable. I have known teeth and roots thus treated to outlast sound teeth in the same mouth clasped at the same time.

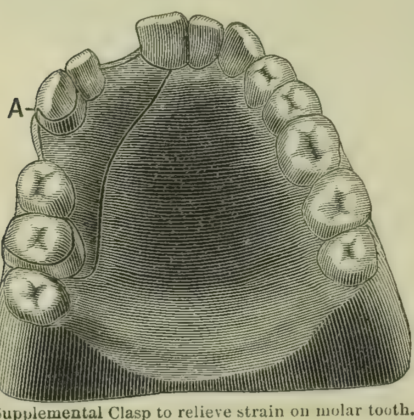
These are matters to be borne in mind. We may also remember that although a neatly-adjusted clasp will often do service for years, apparently without injury to the tooth upon which it is placed, this is not always the case: we may expect more or less injury, and it is well to consider this probability, and, as between two or more teeth, the relative ease with which injury to the one selected can be repaired. When the choice lies between two equally available teeth, the least valuable one should be chosen. I will not attempt to classify the teeth as to their relative fitness: that must be decided in each case, and is dependent as much upon their surroundings as upon their size and shape. The points upon which the usual classification is based are so easily seen, and are so generally appreciated, that I prefer to omit it. Teeth that stand very irregularly in the arch, rendering it difficult for the patient to apply and remove the denture, are unsuitable as organs of support. Incisor teeth, on account of their conspicuous position, are not desirable, and yet quite frequently a small clasp may be fitted to the posterior proximal surface of one of these teeth or to a cuspid tooth that will prove useful in steadying a plate, and be no more unsightly than a filling would be in the same position. It is, of course, always best to locate the clasps so far back in the mouth that they are never seen. It is seldom satisfactory,

FIG. 354.



Badly-arranged Clasped Plate.

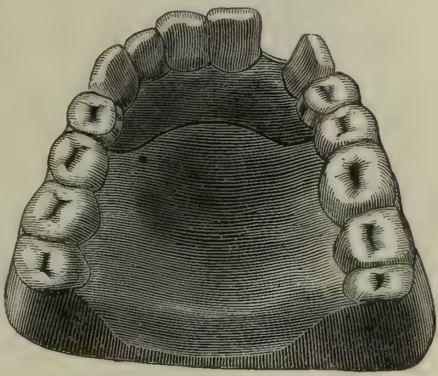
FIG. 355.



Supplemental Clasp to relieve strain on molar tooth.

however, to arrange a plate as shown in Fig. 354. The leverage between the clasped and the replaced tooth is so great that there is not only an unnecessary strain upon the supporting tooth, but there is also apt to be an absence of steadiness in the plate. If a second clasp can be added, as shown at A, Fig. 355, this defect is in a great measure relieved; but it makes a far more desirable arrangement to extend the plate on either side of the arch, with a clasp on each side, as shown in Fig. 356. The slight addition to the size of the plate would scarcely be noticed: it is a question, indeed, whether the edge of the plate occupying the position shown in Fig. 354 or 355 would not be far more annoying than the larger plate.

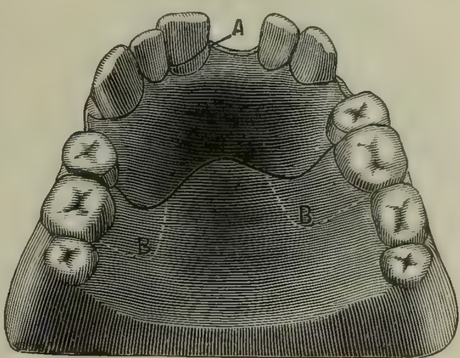
FIG. 356.



Partial Upper Denture supported by clasps.

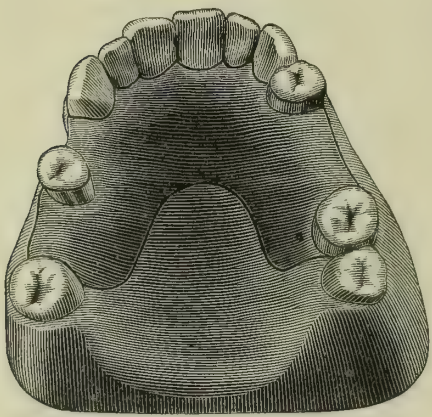
Figs. 357, 358, 359, 360 illustrate various deficiencies frequently met with, and suggest the size and shape of plate and position of clasps appropriate to each. Sometimes, in cases like Figs. 357 and 359, where the clasped teeth are quite short or so shaped that the clasps upon them do not hold firmly, or where the mouth is long and narrow, making the distance between the replaced incisor and the supporting clasp unusually great, it will be best to add to one or both sides a small clasp, technically termed a "half clasp," fitting around the posterior surface of an incisor or cuspid tooth, as at A, Figs. 357 and 359. It is not necessary that it should extend so far forward as to be seen: it is designed to simply steady the plate and prevent its dropping down in front. This may also be accomplished, if the bicuspids are suitable teeth, by placing the clasps upon them instead of the molars; the plate, remaining the same size, is thus balanced and held more securely. This is shown in Fig. 357, the plate being extended to the dotted lines B, B: the clasps remain the same. It is always desirable to avoid filing spaces between teeth to admit clasps: if a space must be made, it is far better to use rubber wedges, and after sufficient space is obtained pack gutta-percha or cotton between the teeth to hold them apart until the appliance is ready for insertion. This may often be

FIG. 357.



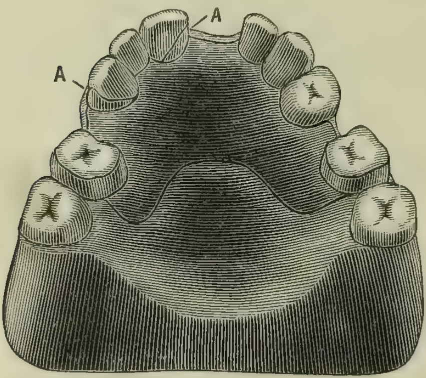
Partial Upper Denture clasped to bicuspid teeth.

FIG. 358.



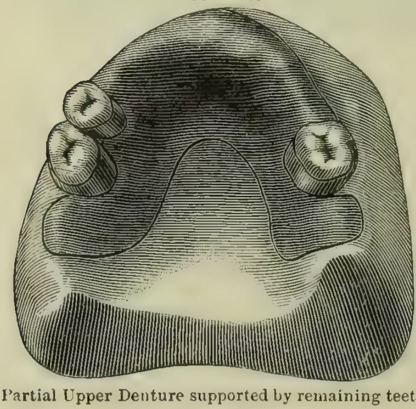
Partial Upper Denture supported by three clasps.

FIG. 359.



Partial Upper Denture clasped to molar teeth.

FIG. 360.

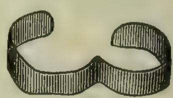


Partial Upper Denture supported by remaining teeth.

avoided by using double clasps, as shown in Fig. 361. They are also frequently useful applied to two adjoining teeth, as the bicuspid and molar in Fig. 360, giving greater firmness with less strain upon the clasped teeth.

Partial suction-plates are made more comfortable by adding "stay" or "collar clasps" on each side: they are small clasps fitting only the palatal surface of the teeth, and are designed to hold the plate when the suction is broken until it can be readjusted by the patient; they prevent the plate from falling upon the tongue, as it otherwise would do. They also prevent any movement of the plate during mastication that would tend to displace it, and by thus holding it firmly add very much to the patient's comfort. The bicuspid teeth are usually selected for collar-clasps, and unless they are strong and firm it is best to use two clasps on each side, so as to distribute the pressure and avoid forcing the teeth outside of the arch. These clasps, to hold well, require to be of a peculiar shape. The upper bicuspid teeth have usually a slight bulge on the palatal surface about midway between the margin of the gum and the cutting edge of the tooth. (See Fig. 362, A.) Advantage is taken of this, and the clasp made to fit under it: to do so the clasp is made to fit the slope of the tooth at the margin of the gum, and to extend slightly, very slightly, under its free margin. The edge

FIG. 361.

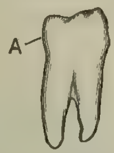


Double Clasps.

of the clasp nearest the cutting edge of the tooth is filed away (usually after the clasps are soldered to the plate), so as to make a downward curve until it fits neatly under the bulge of the tooth. It is surprising how much firmer the clasp holds when thus fitted.

These clasps should be made of quite thin plate: they are not intended to sustain the plate, but only to steady it and assist the suction. It is not necessary they should "press" against the teeth; a close, snug fit is all that is required. Occasionally, clasps of this character are used on one side of a clasped plate where a larger clasp cannot be conveniently fitted. The combinations and variations of clasps are almost innumerable: it is utterly impossible to illustrate or classify them, if indeed it is desirable; the judgment that is capable of selecting a practical form to meet an emergency is equally capable of originating all that is needed beyond the simple suggestion.

FIG. 362.



Section of Bicuspid Tooth: A, rounded portion of palatal surface.

Partial lower plates usually require clasps, but, partly owing to the different shape of the teeth, and partly to the different offices they are called upon to perform, they are of a somewhat different character from those used on upper plates. For convenience of illustration I will refer to two conditions frequently met with in partial lower dentures: First, where the anterior natural teeth are in place and the posterior teeth are to be supplied; and second, the reverse of this. These may be considered typical of all the variations likely to be met with, and will serve to illustrate the principal points in arranging the clasps.

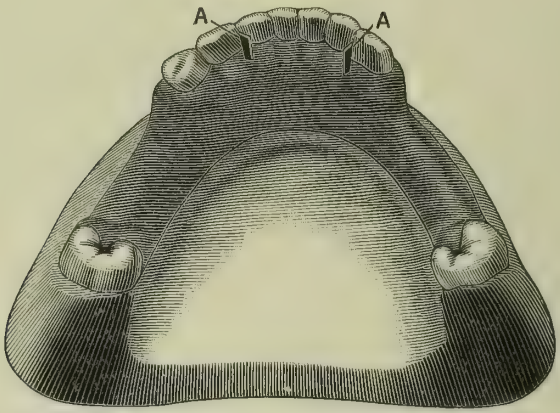
In the first case, shown in Fig. 363, there is usually a tendency in the plate to slide backward, owing not only to the form of the gum, but also to the direction of the force of mastication. Although in arranging the teeth an effort may be made to so adjust them that they will have a forward tendency, after they have been worn a short time the plate will "settle" a little more under the molar teeth than forward of them, owing to the heavier pressure they naturally have to sustain, and then, as a rule, unless restrained by clasps, the plate will begin to gradually slide backward. The clasps are intended to counteract this, and also to prevent the plate from being raised from its place by the various muscles of the lips, cheeks, etc. In fitting clasps to the cuspid teeth, as we are compelled to do where we have only the six anterior teeth in place, let the clasps pass as far into the interspace between the cuspid and the lateral teeth as possible; in many cases the portion that goes between these teeth is the most useful part of the clasp. Always start the clasp at this point in making it, and let it extend around the posterior proximal surface as far as is possible without being unsightly. It is usually best to let it extend well around the front at first (C, Fig. 364), and remove the more conspicuous portion after the denture has been worn some time and the patient has become accustomed to its presence.

When from the position or condition of the teeth, or from any cause, it is not convenient to use clasps, the plate may be nearly as well secured by straight pieces of plate or "stays," extending between, say, the lateral and cuspid teeth of each side, as shown at A, Fig. 363. (In the

cut the plate is shown fitted with both clasps and stays, simply for convenience of illustration; where clasps are used the stays would be useless; the stays are only used where clasps are inadmissible.)

To adjust these stays, finish the plate ready for the teeth, and arrange it in the mouth: while it is in position pass a saw or safe-sided file between the teeth, and make a cut in the plate as deep as the stays are

Fig. 363.



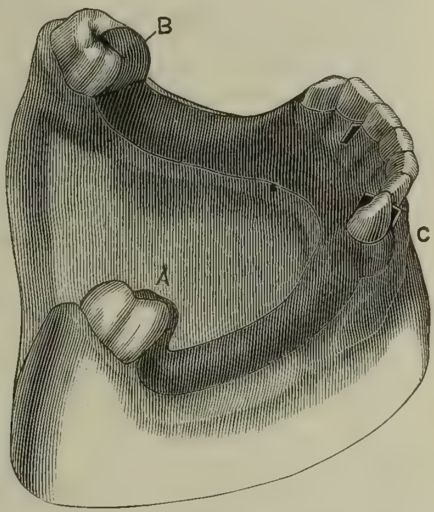
Partial Lower Plate supplying posterior teeth: A, A, stays passing between anterior teeth.

intended to be wide. When this has been done on one side, adjust the stay, making it fit the cut tightly and letting it extend well through the teeth in front for convenience of holding it in place before it is soldered. While the first one is in place arrange the one on the other side in the same manner. In difficult cases it is best to solder the first before beginning the second. When both are ready and in place in the mouth build plaster on the plate and extending over the teeth, so as to well cover the ends of the stays projecting through them. When it is hard remove it from the mouth, adjust any portions that may be broken, and invest it for soldering in a mixture of about equal parts of plaster and sand; when hard, proceed to solder in the usual way. These stays to be useful must be absolutely accurate in adjustment. After they are soldered adjust the plate in the mouth, cut off the surplus length, and file the extreme end rather narrow, either from the top or bottom as may seem best, so that they will not show conspicuously. The lower edge should be slightly bevelled, so as to slip between the teeth easily. These stays hold the plate in place on account of the angle at which they leave the plate. In all cases where there is not room for the clasps to extend around the anterior surface of the teeth particular attention should be paid to making them pass in between the teeth at this point as far as possible.

At times there is trouble on account of the pressure of mastication forcing the plate painfully hard upon the gum. To counteract this, arrange a "catch" attached to the clasp and extending slightly over the crown of the clasped tooth at some point where it will least interfere

with the antagonism of the opposing teeth, as seen at A, A, Fig. 351. Where we have a molar tooth on either or both sides of a case, as in Fig. 364, we may often assist, or even dispense with clasps by fitting a "tongue" (A and B, Fig. 364) to extend up the anterior surface and slightly over the crown of the molar teeth. While this is really an extension of the plate, it is much more conveniently made separate and afterward soldered on. It assists very much in holding the plate in place, and, "hooking" over the crown, transfers the pressure of mastication from the gum to the tooth, very much to the patient's comfort.

Fig. 364.



Partial Lower Plate supplying posterior teeth: A, extension under leaning tooth; B, extension passing partly over molar tooth; C, form of clasp around lower cuspid tooth.

When the anterior teeth are to be supplied, most of the difficulties we have been considering do not exist. The teeth to be clasped are usually better shaped, in a better position to hold the clasp firmly, and the forces tending to displace the plate are more readily controlled. In the case illustrated by Fig. 351, on the right side the clasp may be placed upon the bicuspid, and by filing the end passing around the buccal surface narrow, and so shaping it that it will fit close to the margin of the gum, it will be so covered by the artificial tooth in front of it that it may extend as far round as necessary without being conspicuous. On the opposite side, if the teeth are so close together that a clasp will not pass between them, the two bicuspids may be fitted with stay or collar clasps, to spring lightly against the teeth. On each side it will usually be necessary to add a catch or ear to the clasp passing over the cutting edges of the teeth, to prevent the ends of the plate pressing upon the gum (shown at A, A, Fig. 351). These clasps have little more to do than to simply steady the plate; the force of mastication tends rather to press it into place than to displace it. A careful study in these two cases of the displacing forces to be overcome, and the means suggested to that end, will no doubt suggest methods of meeting any complications that may arise.

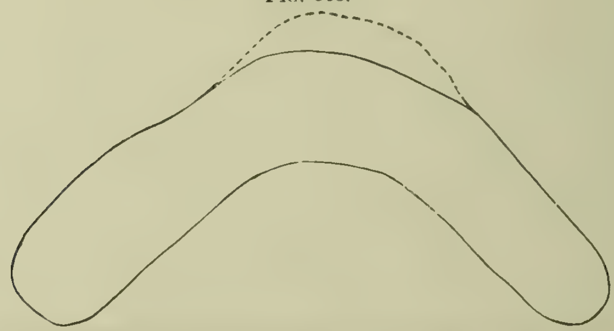
Preparing the Pattern and Metal Form for the Plate.

The next step in making a plate is to prepare a pattern to serve as a guide in cutting to the required dimensions the metal of which the plate is to be made. At first sight this may seem a simple and unimportant matter, but a little experience will soon prove that this is not the case.

Apart from economy in working with the precious metals, having the form from which the plate is to be made the exact size and shape, especially for partial or full lower plates, is not only a saving of time, but enables the workman to produce a better result than when cut to a faulty pattern, for then the metal must be strained and forged, and often torn and split, in adapting it to the dies.

Thin sheet lead or tin is usually recommended for making patterns. For two reasons I consider both objectionable: First, the clippings from them are liable to become mixed with the gold and silver scraps, and, if unobserved, will when they are melted give a great deal of trouble. One part of lead or tin is sufficient to render one thousand parts of gold or silver quite brittle; and both these metals are very difficult to "burn out" or oxidize in the melting furnace. Secondly, while either sheet lead or tin is readily adapted to the cast, there is serious risk that it may be stretched and changed in shape in afterward flattening it out to serve as a pattern, especially in those cases where accuracy is most desired. I much prefer rather soft paper—a piece of newspaper, for instance. In upper plates, either partial or full, there is but little trouble: ordinary care will give sufficiently accurate results. In deep mouths it is necessary to press the paper well into the palatine arch as represented on the cast, or the pattern will be too small at the sides. Place the paper upon that portion of the cast to be covered by the plate, and, making it lie as close to the cast and as free from wrinkles as possible, trace upon it the outlines of the plate with a lead-pencil, and afterward cut it to fit inside the lines accurately. In lower cases, partial or full, it is very necessary that the pattern should give the proper curve as well as the dimensions of the plate; this is especially important in such partial cases as that represented by Figs. 350 and 352. At best, such plates are difficult to make, and any inaccuracy in the curve of the pattern will give a great deal of additional trouble. The usual tendency is to make the pattern too straight—not curved enough—owing to the paper not being held close to the teeth when the sides of the pattern are marked. The same result may occur when sheet lead or tin is used, by the metal being stretched out of shape when it is flattened out. Figs. 365 and 366 will give an idea of the

Fig. 365.

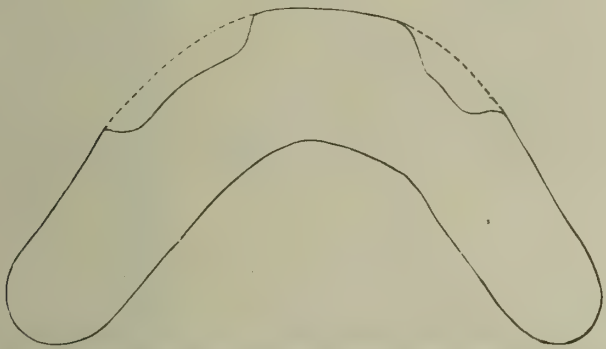


Pattern for Plate for Partial Lower Denture supplying posterior teeth. (See Fig. 350.)

form such a pattern should have for the plate represented in Figs. 350 and 352.

The pattern completed, lay it upon the metal of which the plate is to be made, selecting a position where it can be cut with the least waste, and trace its outlines with a sharp point or tracer, and cut to this line with straight or curved shears as may serve best. In cutting the form for a partial upper plate it is best not to follow the outline of the pattern where it is cut out to fit around the natural teeth, but to leave those portions to be removed after the plate is partly fitted to the die. If the form is accurately cut to the pattern, it must be as accurately adjusted

FIG. 366.

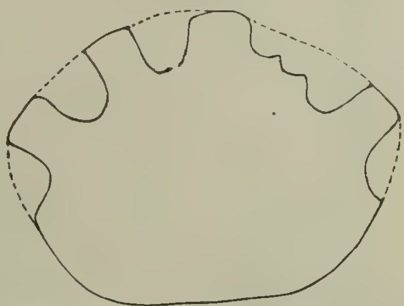


Pattern for Plate for Partial Lower Denture supplying anterior and posterior teeth. (See Fig. 352.)

to the die—in practice a very difficult task. Fig. 367 shows the outline of the pattern—the dotted line, the size and shape to which the metal should be cut for a plate like Fig. 349.[1]

In laboratory practice the gold and silver plate when rolled after melting is left quite thick, probably three or four times as thick as an ordinary plate. The piece for a plate is cut from the stock, and afterward rolled to the right thickness and to fit the pattern. This method effects a notable saving, for while scraps of gold or silver are not really wasted, there is a real loss in the time and expense, and a small actual loss each time they are melted and rolled into plate. It frequently happens that a piece can be cut from the stock and by rolling it in various directions be made large enough for the pattern, and yet leave enough of the stock for another plate; while if it had all been rolled out to the proper thickness before being cut, but one plate could have been obtained from

FIG. 367.



Pattern for Plate for Partial Denture to be retained by suction. (See Fig. 349.)

[1] In Figs. 365 and 366 the metal should be cut larger than the pattern at points indicated by dotted lines: these portions are bent or hooked over the die, and prevent the plate changing its position during swaging.

it. An experienced workman seldom fails in cutting a piece which when rolled to the proper thickness will accommodate the pattern without waste.

Gold, being stronger and stiffer, is usually rolled several numbers thinner than silver; a suction-plate, especially if it has a soldered or Cleveland vacuum-chamber, may be thinner than a clasped plate. A lower plate requires to be several numbers thicker than an upper plate. A plate for a flat mouth, either for the upper or lower jaw, should be heavier than one for a mouth where the ridge is quite prominent or the arch deeper.

Judgment should be used to make the strength of the plate correspond to the strain likely to be brought upon it. Partial plates should have all the weak points stiffened by extra pieces soldered on: it is far better to do this than to make the entire plate excessively heavy, especially as two laminæ soldered together are much stiffer than a single lamina of the same thickness. A full upper plate made of gold may be No. 26, a full lower one, No. 24; if silver is used, make the upper plate No. 24 and the lower one No. 22, American standard wire gauge.

Making the Plate.

We are now ready to begin work upon the plate. First, anneal the metal, heating it to a full red heat, and see that it is hot all over, at the same time taking care, especially when working silver, that it is not made so hot as to be "burned" or "sweated;" that is, fused on the surface. When this has taken place the plate is not only roughened, but its texture is destroyed and it becomes in a measure brittle. It is a matter of no moment whether the plate is cooled quickly or slowly after annealing; usually it is plunged into cold water to save time, and I see no objection to the practice. It should be reannealed every time it is swaged: before doing so, however, it should be placed for a few moments in a bath of sulphuric acid and water, equal parts, technically termed "pickle," to remove any particles of base metal that may have adhered or become attached to it. If they are allowed to remain, when the plate is again heated they become alloyed with it, and either produce a roughness or a hole according to the amount present.

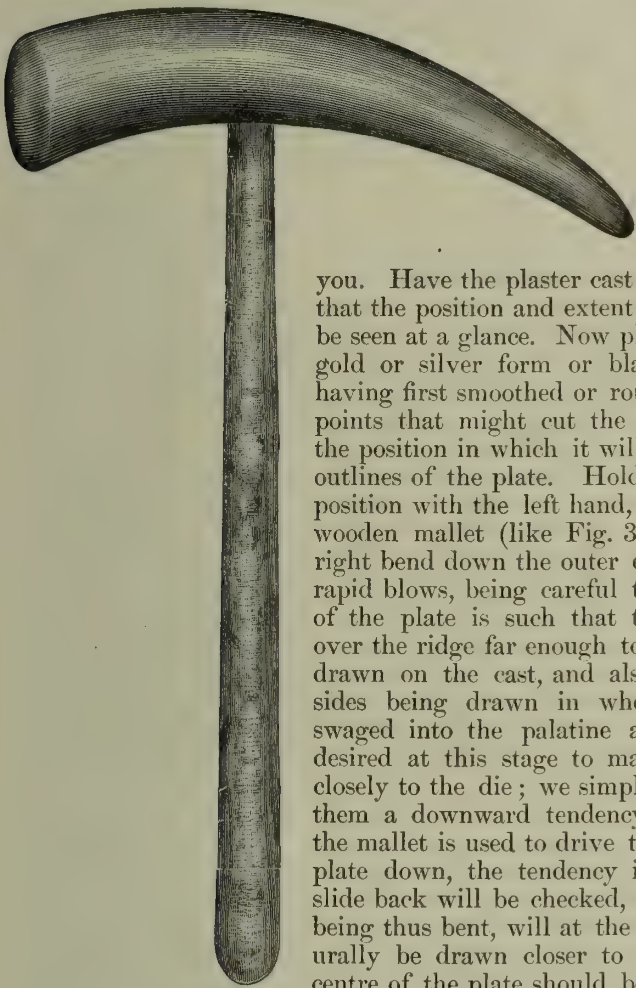
There is but little difference between the manipulation of gold and silver in making a plate, except that the gold, being stiffer and becoming hard sooner, requires a little more manipulation and more frequent annealing than silver. The directions here given apply equally well for gold or silver, and with slight changes, which readily suggest themselves, to the construction of either full or partial plates of either jaw.

For convenience, I will first describe in detail the method of making a full upper plate, and then suggest the changes needful in other cases.

It is best to have a separate bench on which to work with the metallic dies, or to confine them absolutely to one portion of the workbench, as far from the gold and silver drawers as possible, to avoid any accidental admixture of the precious and base metals.

Place on the bench the die selected as the first, or, better still, as it is then much firmer, hold it in the bench vise, the back part toward

FIG. 368.



Horn Mallet.

you. Have the plaster cast near at hand, so that the position and extent of the plate may be seen at a glance. Now place the annealed gold or silver form or blank on the die, having first smoothed or rounded any sharp points that might cut the hands, and note the position in which it will best cover the outlines of the plate. Holding it firmly in position with the left hand, with a horn or wooden mallet (like Fig. 368) held in the right bend down the outer edges with light, rapid blows, being careful that the position of the plate is such that they will extend over the ridge far enough to meet the lines drawn on the cast, and also allow for the sides being drawn in when the plate is swaged into the palatine arch. It is not desired at this stage to make the edges fit closely to the die; we simply desire to give them a downward tendency, so that when the mallet is used to drive the centre of the plate down, the tendency in the plate to slide back will be checked, while the edges, being thus bent, will at the same time naturally be drawn closer to the die. If the centre of the plate should be fitted first, the edges would naturally flare up; the effort to bring them into position would not only tend to again straighten the centre of the plate, but also to stretch and throw the outer edge into folds or creases. When once this movement has started, it is very difficult to control; the pounding necessary to work them out by stretching the plate increases the difficulty.

It is always best, especially in deep mouths, to work the plate well down to the centre of the die with the mallet before using the counter-die. The skilful use of the mallet "draws" the metal into place, while the counter-die is more apt to stretch it; in very deep mouths the plate may even be split if this precaution is neglected. After the plate is

fitted as well as it can be with the mallet, being careful that there are no places around the edges likely to make a fold or crease, place it on the zinc die with several thicknesses of newspaper between the die and the plate, and accurately adjust them to the counter-die. Place them on the anvil with the counter-die down, and while grasping the zinc die with the left hand, holding it firmly in place, strike it a light blow with the large hammer. Examine and make sure that the plate has not moved, as it is apt to do, and then, holding it as before, strike several moderately heavy blows. We simply desire at this stage to fix the plate in position. Remove it from the dies and anneal it. In using the hammer grasp the handle near the head of the hammer, and strike deliberately, firmly holding the hammer down so as to prevent any rebound: the ringing blows that sound so musical in the blacksmith's shop are not the kind to make a solidly fitting plate. If the hammer is allowed to rebound the die follows, and in settling down again slightly changes its position; it requires very few of such blows to produce a plate that no one can make to fit the cast accurately. The character of the force used in swaging a plate is a matter of great importance, not only in making a plate to fit, but also in making a plate that will not *change its fit* in subsequent operations.

Now place the plate on the plaster cast and see that it comes up to the lines. Sometimes in swaging the first time the plate will slip backward or sideways, so that while it does not reach the lines at one point, it overlaps them at another. If this has taken place, it can usually be corrected at this stage by using the mallet to change its position on the die. Partial plates are very apt to slip back; this is often more readily corrected in these plates by placing the plate in the counter-die, bending it so that it will occupy the desired position, and holding it there by raising a burr on the lead just back of the plate with a chisel or graver, and making it lap over the plate with the bench hammer. This expedient comes in use quite frequently to hold a plate securely in place while swaging.

If the plate is all right as to position, trim it off at all points where it extends much beyond the lines, except at points where its position is likely to be changed when it is fully fitted to the die. Then examine the front of the plate; in nearly all cases it is necessary to cut a slit at this point to allow that portion of the plate outside of the alveolar ridge to fit close to the cast without forming a fold or crease. In many cases a V-shaped piece must be removed, but not, however, at this stage. It is seldom that this slit can be avoided, yet it is not desirable to make it too soon: it is best to wait until the plate is fairly well fitted to the die; then simply cut a slit with the shears at the centre of the plate, extending it to near the top of the ridge, but not over it. If it is cut too far the edges are apt to separate at the apex of the ridge, leaving a hole to be either filled with solder or covered with a scrap of plate, either of which is equally objectionable. This is a prominent point: anything added to it will be in the way when fitting the teeth; and, again, it comes so near to where the backings are soldered to the plate that any solder, unless specially prepared to require a high heat for fusion, will be re-fused when the teeth are soldered, and

the result maybe a hole at a point extremely hard to reach for resoldering.

With the mallet bend down the edges of the slit so that they will lap over each other. Then place the plate between the dies as before, and swage it thoroughly. It should now fit the die accurately and be well stamped into the rugæ. After annealing trim the plate nearly to the lines, using for this purpose the shears, plate-nippers (Fig. 370), or files as may be most convenient. Always postpone filing the plate accurately to the lines until it has been swaged to the second die, as otherwise it may be drawn out of position at some point, and thus be made too small.

We will now attend to the vacuum-chamber or suction-cavity. If it is of the Gilbert pattern, swaged with the plate, we will need two special tools to give it a sharp outline and make it fit at its edges close to the roof of the mouth: First, a chaser made of bone. This may be made of a toothbrush handle, one end of which is filed to a moderately sharp, smooth edge like a cold-chisel, but rounded slightly and about one-fourth of an inch wide. This edge will need frequent renewing. It is used by placing the edge of the chaser in the imprint of the chamber while the plate is on the zinc die, and holding it at a slight angle, as we would a chisel in cutting a groove; strike light, rapid blows on the end with the mallet or the bench hammer, so as to drive it down and forward. Pass it round the chamber repeatedly, so as to "coax" the metal in place. If the blows are struck too hard, they will indent the plate, and the indentations, once made, mar the plate and are very difficult to remove. In many cases this bone chaser will complete the chamber. When greater sharpness is required a steel chaser is used, this being about three-sixteenths of an inch wide, with a thin edge well rounded and made as smooth as a burnisher. This is used in the same way; if used to excess it cuts a groove in the plate that must be filled with solder to make a neat finish.

The chamber is only partly finished on the first die; after annealing swage the plate lightly on the second or finishing die, and then complete it.

In fitting the plate the wax model of the chamber on the plaster cast becomes slightly flattened out, so that it interferes with the plate; as its work is done when the dies are made, it may be removed as soon as it is seen that the dies are satisfactory and that a new one will not be required.

A Cleveland[1] or soldered vacuum-cavity seems at first sight to be more difficult to construct than the Gilbert cavity, but with a little practice one is as readily and quickly made as the other. The advantages claimed for the Cleveland cavity are—first, the edges can be made (as will presently be shown) to fit the roof of the mouth more certainly and accurately; and secondly, no matter how soft the mouth may be on account of the cap being made a little larger than the opening cut out of the plate, there is always a space all around the chamber that the mucous membrane cannot fill. The chief objection also rests here: if this space is large and the edge of the opening left sharp, it may prove

[1] Invented and patented by John A. Cleveland of Charleston, S. C., June 25, 1850.

a source of serious irritation. This can usually be remedied in a properly-constructed chamber by making the edges smooth and reducing the space by enlarging the opening in the plate; which can be done after the case is finished and the necessity for it is seen. A second objection is, that this space becomes a receptacle for food, etc., and cannot be kept clean. This is not the case if it is properly made and the space is no larger than shown in Fig. 378. Formerly it was the custom (Cleveland's patent was for a cavity made in this way) to make a Cleveland cavity by cutting an opening through the plate, stamping a second plate upon the same dies, making it large enough to extend from a fourth to half an inch beyond the margin of the opening, and after bending the edges of the second plate so that there should be a slight space between the two plates, they were soldered together. This left a large space so situated and of such a shape that it was impossible to keep it clean. Filling it up with gutta-percha or an amalgam of gold and mercury, and afterward driving off the mercury by heat, as recommended, failed to remedy the evil. At this time it seems strange that they should have ever been so made, but we must remember that the knowledge that we have to-day has been mainly derived by the judicious use of failures; it is far easier to see than to foresee.

Without question, the Cleveland cavity secures a stronger suction and is more permanent than a Gilbert chamber. I may suggest, in passing, that a vacuum-chamber does not cease to be useful after the integument has completely filled it up. The mucous tissue drawn up into the cavity assists very materially to steady and hold the denture in position, although there may be but little suction. We are, however, now dealing with the construction of vacuum-cavities rather than with their usefulness or relative value. Of the many methods of constructing a Cleveland cavity, I have, after an experience of many years, found the following by far the easiest and most practical: First, make a model of copper the size and shape of the cavity, and as thick as the cavity is intended to be deep; the cap is formed over this, and if it is made just as large as the lines marked on the cast, the cap will be the right size to cover an opening cut to them. There is no harm, however, in making the copper form a trifle larger—say, a line all round. To make the model, after cutting it approximately to shape fit it, with a small hammer and pliers, to the first die as nearly as possible in the position it is intended to occupy. Then, holding it on the die by means of a little wax underneath it, carefully adjust it to the counter-die, and swage it up—a single light blow at first, until it is fixed in the right position. It is apt to slip, especially if the workman is inexperienced: with practice it may be fitted to the die so that it seldom moves. The expert acquires a "sleight of hand" in these matters impossible to describe or to teach; it comes through practice.

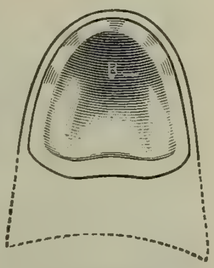
When it is fixed in the right position, swage it up thoroughly. Now with the file reduce it to the right size and shape, it having been left a little large. A slight change in position during swaging can be corrected at this time. Make the edges smooth and slightly and evenly bevelled, so that the surface next the cast is slightly larger than the other, and round off the upper edge just sufficient to take off its sharp-

ness. The artistic skill displayed in shaping the copper model has much to do with the beauty of the chamber in the finished case.

When the model is complete place it on the plate, and, holding it with a pair of pliers or a clamp in the desired position, solder it with silver solder to the plate, either at the back or at the front as may be most convenient, using as little solder as possible, and being careful that the solder flows under it and does not mar its edges. The object is to hold it in place until the cap is made; and as it then must be removed, silver solder is used in all cases, the endeavor being to confine it to as small a point as possible.

Then place the plate with the copper model soldered to it on the second or finishing zinc die; place it in the counter-die and lightly swage, just sufficient to make an imprint of the copper in the counter-die. With a graver or small chisel cut this imprint a little deeper than the thickness of the copper, being careful not to mar the edges, and then replace the plate and die and swage as before. Ascertain if this manipulation has marred the edges of the copper; if it has, restore them. To do this it may be necessary to remove it from the plate; there is no objection to this, as it can be replaced and secured with wax-and-rosin cement. To form the cap take a piece of metal sufficiently large for the purpose—it may be two or three numbers thinner than the plate—and, after bending it with the hammer or pliers so that it will approximately fit the counter-die, secure it over the imprint of the chamber, either by turning down two opposite corners and driving them into the lead, or by raising a burr on the lead with a chisel at several points, and with the hammer making them lap over the edges so as to hold it in place. In many cases it may be so fitted that without being thus secured the risk of its moving is slight. Carefully adjust the die into the counter-die and swage lightly—a single light blow is sufficient; examine to see that the cap extends at least one-sixteenth of an inch over the copper model, and also that the edges of the imprint have not been marred. The model with the cap over it being a little larger than it was without it, it often happens that the lead is crushed in at the edges; this must be cut away. Anneal the cap and again swage it up, carrying it "well home;" this also swages the plate. Then trim the edges of the cap, allowing them to extend beyond the copper a full sixteenth of an inch, and endeavor to make the margin the same width all round; then bevel the edge from underneath—that is, the surface of the margin that lies against the plate. Let the bevel extend about half its width, and make the outer edge quite thin, so that it will be completely covered with solder when soldered to the plate. The cap thus made is shown in Fig. 369. Some prefer to finish the edge of the margin square, making the solder flow under it, so that it is seen when the case is finished. This is objectionable; it has no practical advantage, and must be very neatly done to be at all sightly, and even then leaves a crevice all round the chamber difficult to clean. If the edge is bevelled, as it should be,

Fig. 369.



Cap for Cleveland Vacuum-cavity.

and made to lie close to the plate, the solder flows over it, making a neat, smooth finish. Other operators prefer to make the posterior edge of the cap extend over to the posterior edge of the plate (as shown by dotted lines Fig. 369), thus thickening the edge of the plate at this point,

Fig. 370.

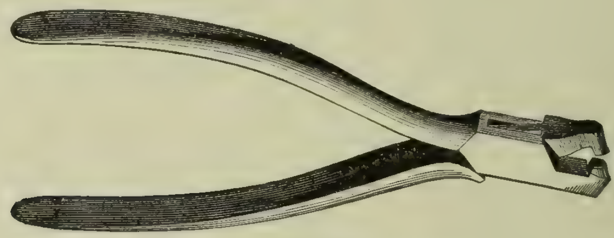


Plate-nippers.

and permitting a portion to be filed away should the plate at any time press too heavily upon the hard palate.

The cap having been formed, remove the copper by placing a point between it and the plate, so as to spring them apart, and heat up under the blowpipe; usually it will come off just before the solder flows. The next step is to cut the opening through the plate (Fig. 371), and in doing so keep a little inside of the marks made by the copper. The opening may be made by punching a hole large enough to admit the saw-blade and following the outline with the saw; but on account of frequent breakages saws are expensive, so the opening is usually formed by either punching a row of holes along the outline as close together as

Fig. 371.

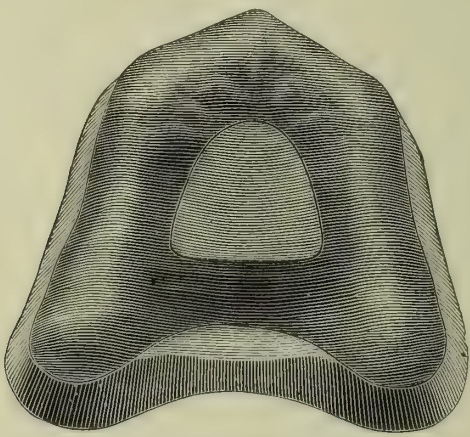


Plate with Opening, ready for soldering cap for Cleveland vacuum-cavity.

possible with the punch, and breaking away the enclosed metal, or by cutting a hole in the centre with the plate-punch or nippers (Fig. 370), and then enlarging with that instrument to the required size, in each case completing the operation with the file. Either of these methods

is as easy and rapid as the saw, so that I seldom use the saw except where it is desired to use the portion cut out to form the cap; which may be done by cutting it out accurately and rolling it so as to be large enough.

While finishing the opening try on the cap, so as to avoid making it either too large or too small, and also examine the plate on the cast, to see that the opening corresponds with the marks upon it. Make the edges square, not bevelled, and finish them smoothly with fine sand-paper. Soldering half-round wire around the edge has been recommended to make it thick and less likely irritate the mucous membrane if drawn through into the chamber. I consider it a clumsy expedient and wholly unnecessary: irritation occurs in but few cases, and these are readily relieved by enlarging the opening, so as to remove a portion or all of the projecting edge.

We will now return to the plate. First examine the cut made in front or at other points to allow that portion of the plate outside of the ridge to fit closely to the die. If the edges lap over very much, cut off the excess, being careful to leave enough to lap over well; bend them apart and bevel the inside of one edge and the outside of the other, so that when they come together there will be little or no increase of thickness. Place the plate between the second set of dies and swage thoroughly, being careful that the blows are struck firmly and squarely upon the centre of the die, so as not to tilt it. Three or four well-directed blows are usually all that are needed. In using the first die I frequently direct the blow along its edge, to thoroughly swage the ridge, or strike the back edge to drive it forward, so that the outer border may be brought up close; or reverse them on the anvil, allowing the hammer to fall upon the counter-die, so that all parts of the plate may be thoroughly swaged. While this is permissible and necessary on the first die, it would ruin the second.

The plate should now fit the cast accurately. Trim the edges of the plate all around accurately to the lines on the cast, and solder the cuts that have been made in fitting the plate, using as little solder as possible; be sure that the solder runs through. It is better to use for this a hard-flowing solder, so that it will not be re-fused in subsequent solderings. A hard-flowing solder can be made at any time by alloying the solder usually employed with from one-half to its own weight of plate. This method of making hard-flowing solder applies to both gold and silver. A few grains can be made under the blowpipe and flattened out on the bench anvil; I find it more convenient to do so than keeping both grades in stock. If the plate has a Gilbert chamber and fits the cast after soldering, it is ready for the finishing touches presently to be described.

If the plate has a Cleveland cavity, the cap and the copper model should be in position, and all be swaged together when the second dies are used. After soldering the cuts made in fitting the plate, and filing the edges accurately to the marks on the cast, swage the plate by itself lightly; then place it on the plaster cast and see that the edges of the opening for the chamber fit closely to the roof of the mouth. It is usually necessary to set the edges down slightly by striking them with

the edge of a small hammer while the plate is on the cast. It is very important that the plate fit accurately before the cap is soldered in, as it is a difficult matter to reswage afterward. If all is satisfactory, scrape the plate where the solder is intended to flow, apply borax mixed to a creamy consistency to the edges of the cap and on the plate where it is to fit, and place the cap in position. Usually if the cap is held in place with a point until the blowpipe flame has dried the borax, it will not change its position when the solder flows. It is best to apply a small piece of solder at the back part of the plate, and apply sufficient heat to fuse but not flow it, so that it will hold the plate and cap together; then if any change should take place they can be separated easily and without injury. Let it cool; if the edge of the cap does not lay close to the plate all round, place the plate on the cast and burnish it down. Place the plate on the charcoal support, being careful that it is so evenly held as to avoid bending by its own weight when made very hot: this is an important point, especially with silver plates, and should never be neglected. In completing the soldering begin in front and flow the solder all round, applying the heat so that the solder will flow under the cap and not over it. Sometimes it is necessary to hold the cap in place with a pair of narrow-nosed pliers kept for the purpose, letting them take hold of the margin at the back part. Clamps are also used for this purpose, but are apt to bend the plate: a very little force will do that when plates are heated sufficiently to flow hard-flowing solder.

The plate is now ready for the finishing touches. It has been asserted that a plate cannot be swaged upon zinc dies to fit the plaster cast from which they were made, and that it is better not to attempt to make any change in the plate after the last swaging. This I consider a serious error. I have always made plates fit the casts, and if the casts are accurate the plates will then fit the mouth. The changes due to the expansion of plaster and the contraction of zinc are so very minute that practically they may be ignored. Misfits are far more likely to occur from unskilful manipulation in making and swaging the plate, or from imperfect dies, or dies made of too soft a metal. By a "misfit" in this connection I mean a plate that does not and cannot be made to fit the plaster cast by any permissible manipulation; many plates as they come from the dies apparently do not fit the cast, nor would they fit the mouth at all satisfactorily, and yet by skilful manipulation they are made to fit both perfectly. The dental mechanic has the cast as his only guide; it is presumed to be accurate, and the plate *must* be made to fit it. For him to assume that his metallic dies—copies of the cast made by a process liable to give inaccurate results even in the most skilful hands, and liable to be injured in use—are a more perfect fac-simile of the mouth than the plaster cast taken directly from the impression of the mouth, is absurd. The change likely to take place in the plaster is trifling compared to that likely to occur in the process of moulding and casting the dies.

I desire to lay particular stress upon this, and shall enter more into detail regarding the final fitting of the plate to the plaster cast than I would were it not for the fact that the text-books and the dental periodicals furnish so little information in regard to it. This may be owing

in a measure to the difficulty of treating a subject that is so largely a matter of judgment and of special skill to be acquired only by experience.

I will first consider what constitutes a perfectly fitting plate, and then consider the perplexities met with in the effort to secure it. I am still referring to a full upper plate, but consider this a type of all: the special manipulation required for other plates is far less than their difference in form and character would suggest.

Place the plate on the cast, and observe that it goes on freely; that is, that it is not necessary to press it on. Unless the ridge overhangs, the plate should fall off if the cast is reversed. If the plate "springs" on and binds at any point, it may appear to fit when it really does not. Then press upon the vacuum-chamber. This should not give or "spring;" if it does, the plate fits too tightly outside the alveolar ridge. This of itself would be no fault, but as it probably prevents other and more serious defects from being seen, it must be corrected. We now wish to see whether the plate is in close contact with all parts of the cast it covers, and also that it does not press harder at any one point than another. To do this hold the cast in both hands, the face of it up and the back part toward you; with the first finger or thumb of each hand proceed in the following manner: Place the finger or the thumb of the left hand on the little elevation usually found on the ridge immediately in front of the mouth, and the finger or the thumb of the right hand on the extreme back edge of the plate; pressure on either of these points should not cause any motion of the plate. If pressing in front causes the back edge to rise from the cast, or *vice versâ*, the plate is said to "rock." (I desire to add here a word of caution. In pressing at any point on the ridge let the pressure be straight and direct. If in pressing at the point indicated in the front of the mouth the pressure should be directed *outward*, it would raise the back edge of the plate, although the plate might fit solidly; if it was directed *inward*, it might not raise it, although the plate might fit very imperfectly. This is a point to be borne in mind.)

Keeping the finger on the point in front, press upon the condyle, and then pass the finger along the ridge from the condyle toward the front, and observe whether, on pressure at any point, the plate is displaced or not, or whether it is pressed down at any point, and when the pressure is released springs back again. This is termed a "spring," and whether a serious defect or not depends upon its location and extent. Then change the position of the fingers, and press upon, say, the most prominent point of the right condyle immediately over the ridge and on the left side, about the position of the cuspid tooth. Do this for each side. Then press upon each condyle; we are apt to find a spring here, owing to the plate being "drawn in:" this may be remedied by slightly "springing" it out; that is, by spreading the back part of the plate, being careful that while correcting this defect we do not cause another at some other point. It is not absolutely necessary, perhaps, that these manipulations should be followed in the order here given, and yet there is great advantage in always following the same order, and systematically going over a plate and determining where it does and where it does not fit, before any attempt at correction is made.

A very slight change will often correct several defects, while perhaps if the first defect noticed should be immediately corrected without reference to the possible presence of others, it might lead to serious trouble by producing other defects. All this is to be done, and the defects that may be discovered corrected, before the extreme edge of the plate receives any attention. It is a very easy matter, without intending to be dishonest, to slightly bend in the edge so that the plate will appear to fit the cast solidly, and yet when placed in the mouth—which yields to pressure, while the cast does not—it will be found a very imperfect fit. The edge fit is far less important than the general fit of the plate; when that is correct, the edge can be made to fit closely at all points by slightly bending with narrow-nosed pliers or by striking the edge with the hammer while the plate is on the cast. (And here another caution: It should always be the workman's pride to preserve the cast in as perfect a condition as possible when the case is done. It is often necessary to use the hammer in fitting a plate to the cast, and yet the marks of the hammer if skilfully used need never be seen.)

When the hammer is used in fitting a plate to the cast, the cast should always be held in the hand, and should be so grasped that the plate is firmly held in place at the same time. The blow need not be heavy, and is usually struck with the riveting blade of the hammer. If the cast is allowed to rest solidly on the bench, the blow is less effective on the plate and far more destructive to the cast. The edge should be made to fit close to, but not to sink into, the cast. When using the pliers in this operation do not turn the edge in; if so done, it will invariably hurt when placed in the mouth: lightly grasp the plate in the pliers and gently "bear" it in the desired direction. The centre of the back edge of the plate should never be made to press hard; usually this part of the mouth is hard and unyielding, while on either side its condition is just the reverse. It is therefore better to allow it to fit rather loosely. When the plate is found free from rock or spring when tested as suggested, and the edge fits closely all round, neatly round the edges by going over them with a dead-smooth file, using it somewhat as though it were a burnisher, and after following this with fine sandpaper the plate may be considered finished.

I will now consider some of the many remediable defects found in swaged plates when they leave the dies, and suggest such methods for their removal as have been found effective in laboratory practice. When the plate "springs" on the cast, owing to that portion outside the ridge pressing hard upon it—or, to use a technical expression, when the plate "binds"—first locate the point in fault. Sometimes we may "feel" where it is, or it may be seen on the cast by a bright or rubbed spot. If the condyles are prominent, it will often be located there or on any prominent point, or it may be more general and extend for some distance. If it is confined to one spot, gently bear the plate out at that point with a pair of pliers. If it is more general, take the plate in both hands, the thumbs just meeting on the palatal surface at the centre of the back edge, and the first and second fingers of each hand pressing just inside the ridge on the lingual surface, and, holding it

with the back edge toward you, slightly spread the plate: do it very gently and very little at a time, or it may be overdone, and that is a much more difficult matter to correct. This may throw the edge out a little, but that is so readily corrected that we may disregard it. This binding outside of the ridge will often cause the centre of the plate to spring from the cast; in that case it may be better to reverse the plate, letting the thumbs rest at the same place on the lingual surface. I prefer in all cases, wherever possible, to effect these corrections without using the dies, as the dies, while correcting one fault, so frequently cause another. Sometimes I lay two or three thicknesses of newspaper, damped so as to bend to the cast, over the point where the plate binds, and, placing the plate on the cast, strike it a few light blows inside the ridge with the face of the hammer.

When the plate rocks on any prominent point, place from one to several thicknesses of thin paper on the corresponding point on the die, sufficient to make the plate rock on the die a little more than it does on the cast, and after scraping away a little from the same point of the counter-die lightly swage the plate. When a Cleveland chamber is used, this must be done before it is soldered in; if the plate fits well then, and is properly supported while being soldered, there is very little risk of its changing its shape during that operation. These rocks are usually caused by the die being either imperfect or by its crushing down when in use. Sometimes we have a rock from the plate pressing at a point about halfway between the condyles and the position of the cuspid tooth; this may be caused by the peculiar conformation of the jaw, or by the cast having been rocked or tilted in the sand when the mould for the die was made, or by allowing the plate to extend too far over the lines when it is swaged up. It is always best to trim the plate approximately to the lines as soon as it is sufficiently in shape to allow it to be done safely. The excessive surplus gives the plate greater rigidity and interferes very much with the process of swaging. I again repeat, in starting a plate always bend down the outer edges, so as to slightly turn them over the ridge, before attempting to fit the centre of the plate. This applies to all plates that extend over the ridge, either upper or lower, full or partial. The reason for this is, that the outer edge of an unswaged plate is always too full; that is, it occupies a less circle in the finished plate than it does in the blank from which the plate is made. If the outer edges are bent down first, driving down the centre of an upper plate or the inner edge of a lower one will tend to bring the outer edge closer to the cast; but if this is reversed, and the centre or the inner edge of the plate first brought into position, the outer edge is bent away from the cast, and rigidly held in that position by the shape into which the plate is now bent, and the metal is strained and stretched by the manipulation necessary to again work it down to the cast. I consider this of sufficient importance to refer to it in this connection, as I have no doubt that a great deal of trouble in fitting plates and from plates warping in soldering is due to the practice so generally recommended in the text-books of first fitting the centre or inner edge approximately into position. A single trial of the two methods in making an upper plate for a mouth with a high arch, or a

lower plate for one where the ridge is sharp and prominent, will be sufficient to demonstrate the advantages of the plan suggested.

It should be borne in mind that in swaging a plate the metal is not only bent, but it is also stretched in some parts and is contracted in others: there is a certain amount of movement among the atoms of the metal itself of character like to that which occurs when a metal is melted and cast in a mould, but of course only to a very slight degree. The same change takes place to a still greater degree, and is perhaps more readily seen and appreciated, in the operation of metal-spinning. It is important, therefore that the metal should be frequently annealed, and the plate swaged until the form given it by the dies becomes natural to it. The fact that a plate fits the die and does not fit the cast from which it was made with the same accuracy is not absolute evidence that the die is imperfect; the die may have been accurate, and in swaging the plate the prominent points upon it may have been crushed, or the plate may really fit both, but, having been swaged to the die, clings to it so closely that the rock or spring it has when placed on the plaster cast is not noticed. From the shape of the mouth or the character of the alloy used for the plate it is sometimes very difficult to swage a plate to fit solidly; there is a certain amount of spring or elasticity in the metal that prevents its "bedding" down to the die. Hence the necessity for the manipulations I have suggested.

If the dies are imperfect—and it is possible to have very great inaccuracy in a die without its showing on the face, and also possible to have a die perfect on the face that will not swage a plate accurately, for the reason that either the die or counter-die is not level or is badly shaped, etc.—in these cases the misfit is usually so marked that the cause is readily recognized, at least by an experienced workman. It is always best to trace each rock or spring to its cause; by so doing we soon learn whether the fault is or is not in the die, and by knowing how the defect has originated we are better able to correct it. If the die is found imperfect, it is useless to attempt to fit the plate with the hammer and pliers. The defects I have referred to are always slight, and seldom require more than a few minutes for their correction, and yet may be serious enough to prevent a plate fitting the mouth satisfactorily. They are not due to contraction of the metallic die, but rather to practically unavoidable causes. It is unnecessary to give the endless variations that may be met with; care and judgment will prevent many, and may be relied upon to correct all.

Aside from the difference in the form of the plate, and the manipulations incident thereto, the process for constructing a plate for the lower jaw differs but slightly from that already described in connection with full upper dentures.

If the lower plate is constructed from a single lamina of gold or other metal, it should be somewhat thicker than that used in an upper plate. Some prefer to make lower plates double, on account of their extra strength and stiffness when so made, and also because the edges, being thicker, are supposed to be less likely to cut or irritate the gum or adjacent parts. In that case each plate is made thinner—say, No. 28 for gold and No. 26 for silver.

In constructing a double plate make each plate separately, until both are swaged to fit the cast accurately, but do not trim them quite to the plate line, letting the one that is to be underneath extend a little beyond the other. Then thoroughly cleanse the surfaces that are to be in contact and coat them with borax ground to the consistency of cream: the borax should be ground very smooth, as any gritty particles between the plates when they are swaged together will mar the surface of the plates. Then place them between the dies in the relation to each other that they are to occupy when soldered, placing a thickness of paper on either side so that they will not come in contact with the dies, and swage the two together. The paper is used to avoid the necessity of "pickling" them before soldering. Usually when swaged together they are brought so closely into contact that if carefully handled they hold together with sufficient firmness to be laid upon the charcoal and soldered without separating; it is desirable that they should do so: if they do not, hold them together with binding wire at, say, three or four points. I prefer the binding wire for this purpose, using annealed iron wire, about No. 24. It is far less likely to change the shape of the plates than clamps. It is used by placing around the two plates a piece of wire, and twisting the ends together until they are tight enough to hold the plates in position. Twisting the ends together practically has the tightening effect of a screw; the pressure exerted can be accurately adjusted, and remains as it is fixed: it does not, like a spring clamp, tend to bend the plates when they become more pliable under the heat required to flow the solder. In placing the wires around the plates twist the ends across the upper part of the plate; in this position they are less likely to bend the edges of the plate closer together; do not twist them quite as tight as desired. After all are in position, slightly bending the wire that passes across the edges, either by pressing it in with a blunt instrument or by taking hold of it with the pliers and slightly twisting it, will make it sufficiently tight, and yet without holding so rigidly as to bend the plate. Always make it a rule to twist the ends of binding wire in one direction: it is in all cases a matter of choice, and the habit once formed of doing it in a certain way will avoid the annoyance of disturbing the wire by twisting it in the wrong direction when making the final adjustment before soldering. Binding wire can be used to advantage in so many cases that it is well worth while to acquire readiness and skill in its application. Using one wire in front and one on either side near the condyles is all that is usually required; if there is a tendency in the plates to spring apart at any point, an extra wire or two may be used to restrain it. When adjusted place the plates on the charcoal, in most cases with the lingual surfaces downward, but in some cases, where the ridge is flat and the plates wide, this may be reversed. Be careful that they are supported at all points, so that they shall not bend by their own weight when heated, and after adding a little fresh borax at the edges place a few narrow pieces of solder on the edge of the lower plate where it projects beyond the other. The object of this projection is to afford a lodgment-place for the solder, and the projection is made on the lower plate, so that if the solder falls off it will not fall inside, where, if unnoticed, it would be fused and form a projection on the sur-

face that comes next the gum, and in a position where it is very troublesome to remove. Endeavor to apply the solder to one edge only, a little at a time, and by skilful application of heat "coax" it to run entirely through to the other. It is very desirable that the plates should be thoroughly united at all points; if a small portion remains unsoldered the plate will be apt to rise up at that point in subsequent solderings, forming what is technically known as a "blister."

After soldering file the edges of the plate to the marks on the cast. The plate may require reswaging after soldering, but if made to fit accurately before, and carefully handled during that operation, it is seldom that there is any material change in the fit. It is a serious mistake to depend upon subsequent reswaging, and to solder the plates together before they fit the cast accurately. After the plates are soldered together they become quite rigid, and while a slight warping may be readily corrected by the dies, it is very difficult to effect any material change in their shape.

I think it is seldom that this form of plate has any special advantage. The claim that two thin plates made separately and soldered together can be made to fit more accurately than one thick one is not borne out in practice. A plate sufficiently thick for all practical purposes can be made to fit any cast as readily and as accurately as a plate made in this manner. We must also consider the risk of impairing the fit, etc. by the solder with which they are united being re-fused when the teeth are soldered on. The thicker edge is an advantage, but this can be more readily attained by soldering a half-round wire all round the edge of a single plate, giving a thick rounding edge with far less expenditure of material and time. This wire is added after the plate is entirely finished and fitted to the cast. A narrow strip of plate may be used, but the half-round wire gives a neater finish and can be made to fit the plate with far greater facility. The wire should be quite light—say, one-sixteenth of an inch wide on the flat side. It is soldered to the plate in the following manner: Take a piece of half-round wire long enough to go around the edges of the plate, inside and outside, and, beginning at a point about an inch from either end of the plate (it is a little more convenient to begin on the left hand, inside), lay the flat side of the wire against the plate, and with the pliers bend it so that it will fit accurately along the edge for about an inch, holding it in place with binding wire applied in the same manner as described in making a double plate. Do not begin at the end of the wire, but leave enough to go well round the nearest condyle. Then solder this in place, being careful in doing so not to melt the wire. Proceed to fit the wire to the plate, working in both directions from the point soldered, and as fitted secure it with binding wire. Make the edge of the wire lie exactly on the edge of the plate. There is a tendency in the binding wire to draw the half-round wire too far in: this is corrected by placing the edge of one blade of a pair of pliers on the binding wire (after it has been made tight), just beyond the edge of the half-round wire, and the other blade at the edge of the plate; a slight pressure will bend in the binding wire and hold the half-round wire securely in place. Care is necessary in rounding the ends of the plate at the condyles to make the wire lie

perfectly flat; it is apt to touch the plate at the outer edge, while the inner edge does not. A skilful workman will generally at this stage fit the wire all round and complete the operation in one soldering; this is not necessary, however: there is but little risk of warping the plate by repeated solderings if the plate is well supported. In applying heat do not direct the flame directly on the wire or it will spring away from the plate. In soldering do not use too much solder, and apply sufficient heat to make it flow freely. If the case is to be rimmed, omit the wire from that portion the rim will occupy. It has been suggested to turn the wire on its edge along the outside of the plate, so as to form a rim or socket for the reception of the plate extremities of the teeth. This never makes a neat operation: whenever a rim is desired, it is far better to adjust and solder a separate strip to the plate in a manner to be presently described. "Wiring" a lower plate, as this operation is called, is a great improvement, and, while adding very much to its appearance and strength, makes it more comfortable for the patient.

Before commencing to form a lower plate upon the dies, where the ridge is sharp and prominent, it is better to give it a gutter form by the use of the lower-plate bending pliers (Fig. 372), or where these are not at hand

FIG. 372.

Plate-bender for Lower Plate.

this may be readily done with the blade of the bench hammer, the plate being held over a V-shaped groove formed at the end of a piece of hard wood firmly held in the bench vise. The plate thus prepared can be fitted to the dies more rapidly and with less injury to the metal of which it is made than if the work was entirely done upon the dies. Where the ridge is wide, however, it is better to form it over the dies, slightly bending the outer edges down first and then fitting the inner portion as recommended for making upper plates. In all respects the manipulations in making, fitting, and testing the fit of a lower plate are so nearly like that just described for an upper plate that it is not necessary to repeat them.

A partial upper plate is constructed in very nearly the same manner as a full upper plate; the slight differences in manipulation are so self-evident that it is not necessary to describe the process in detail. It is always best to have the pattern a little too large, so as to allow for the plate's slipping out of place slightly in the early stages of swaging, and to remember that in most cases there is a tendency in the plate to slide backward during that process. It is frequently necessary where the

plate is quite small to fit it into position in the counter-die, and hold it in place by cutting burrs in the lead at various points and turning them over the edge of the plate with the hammer. Swage lightly until the plate is well fixed in position, so that if it does slip out of place it can be readily readjusted. Only approximately fit the plate around the teeth, especially the front teeth, until the swaging is complete, as the plate is apt to draw away from them during that operation: I prefer in all cases to leave the final fitting until the clasps are soldered on, or in a suction-plate with a Cleveland cavity until the cavity is soldered in. In all partial upper plates the portion which passes in between the remaining teeth should be strengthened or reinforced; an additional thickness also in most cases is needed to strengthen the attachment of clasps. Usually these are added when the teeth are soldered, and the required pieces of plate can generally be fitted with sufficient accuracy with the pliers, but occasionally, on account of the irregular form of the plate, they must be swaged to fit. When this is the case it should be done while the plate is making, and they should be soldered in place before the plate is swaged for the last time.

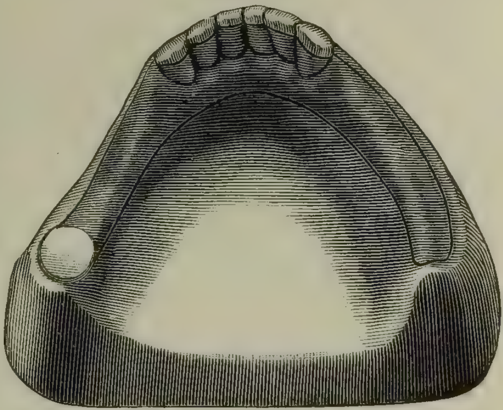
A partial lower plate, if the teeth are scattered and stand at various angles to the ridge and to each other, as they frequently do, severely tasks the workman's skill and ingenuity. In difficult cases I prefer to take a plaster impression in sections of that portion of the cast to be covered by the plate, and from this make a duplicate cast on which to construct the plate. By this method we frequently make a very difficult case quite simple, as all superfluous portions of the duplicate cast can be cut away; and also—a matter of very great importance—we preserve the original cast from injury. We must always bear in mind in these cases that making the plate is only one of the difficulties encountered: the plate must not only fit the cast, but must be so made that it can be placed in position in the mouth. Some teeth that stand at an angle will spring a little to allow the plate to pass over them; others will not: for this reason it is best to make the plate so that it can be readily placed on and removed from the cast. We can in most cases fit a plate more readily to the cast than to the mouth, but if the cast has been broken or marred it ceases to be an accurate guide, and may cause hours of tedious work in fitting in the mouth the finished denture.

The cast is far more liable to be injured in the earlier stages of making the plate than after it is nearly complete, and we find the time required to make the duplicate cast is amply repaid by having an accurate guide in the uninjured original cast on which to fit and arrange the clasps and teeth.

In fitting around the teeth a partial lower plate it is not cut away as is an upper plate to conform to the line of the gum, but is allowed to pass up over the teeth and is made to fit closely to them. This is done partly to give greater strength to the plate by increasing its width, and partly to allow it to rest on the teeth, and thus assist the narrow ridge to bear the pressure of mastication, as previously explained. It also makes a more comfortable plate, as the edges are not so liable to press into the gum, nor yet are they so perceptible to the tongue.

When the teeth to be supplied are all together and in the anterior portion of the mouth, as in Fig. 351, we file the teeth from the first zinc die nearly to the line of the plate on the lingual side, and sloping on the buccal side so as to make a sharp angle, carefully taking off the edge from the front tooth on each side, so that it will not split the plate. The object of filing the teeth from the die at an angle is that the plate may hook over them, thus preventing its being driven down in swaging. We then proceed as in making a full plate. When the teeth are soldered on, a heavy piece of plate, extending from the clasp on either side to the backing of the nearest artificial tooth, is added, so as to strengthen the plate at that point; an extra piece is not needed in front, as the shape of the plate, the backings of the teeth, and the solder give it all the stiffness needed.

Fig. 373.



Metallic Die for partial lower plate (Fig. 363).

When the front teeth are in and the back teeth of either side are to be supplied, as shown in Figs. 350 and 363, we have a much more difficult task. In this case the front teeth are filed from the first zinc die nearly but not quite to the line of the plate, as in Fig. 373, and sloped so as to leave a sharp edge, over which the plate is bent so as to hold it in place during the process of swaging. The molar teeth in a case like Fig. 363 are cut off, so as to leave only enough of the teeth to make a slight indentation in the plate to serve as a guide in filing it to fit around them. In some cases instead of cutting off the molar teeth I prefer to make saw-cuts as close to the gum as possible, and let the ends of the plate pass into them when fitting it to the die, so as to assist in holding it in place. There is usually some little difficulty in commencing a plate of this kind. It is apt to slip back, or when driven up to the front teeth it does not well cover the ridge on each side. After partially fitting it with the mallet it may be placed in the counter-die and securely held in place by means of burrs raised from the lead and slightly swaged, so as to fix it in position. When either side works out of place it may be brought back by the same means. Until the plate is well fixed in position swage lightly and anneal frequently. In swaging lower plates there are several points that require special attention: First, the tendency in the plate to slip down in front: this is prevented by making it hook over the front part of the die; and this portion should not be removed until the plate is so far advanced as to be ready to swage upon the second die. Second, a tendency to fold over or form a crease, generally about the position of the cuspid teeth. This must be watched and the fold hammered out as soon as seen and before it becomes fixed.

Third, the plate is liable to split at about the same points, and also, in some cases, about the middle of that portion of the plate covering the outside of the ridge on either side. Frequent annealing, skilful use of the mallet, and cutting away the surplus metal at these points as soon as it can be safely done will usually prevent it.

It is very desirable that those portions of the plate covering the lingual surfaces of the natural teeth should fit closely to them and into the interspaces. To accomplish this see that the dies are accurate at this point. Usually the portion representing the interspaces needs a little carving. In the first die this may be overlooked, but the second should at this point be made as accurate as possible. After the plate is swaged as much as thought necessary on the first die, anneal, and, holding it firmly in place on the die with a hammer or mallet and the bone chaser used in making a Gilbert vacuum-chamber, drive it into the interspace and the festooned outlines of the gum of each tooth. If these interspaces are deep and sharp, strike light blows, going over it a number of times, and if need be annealing the plate during the operation so as to "coax" it into place. The edges of the chaser will need frequent resharpening, as it breaks down rapidly. Be careful not to cut through the plate; this accident will occasionally happen, and, while not usually a serious mishap, should be avoided. This operation usually bends the plate very much out of shape; it is therefore best to only approximately trim the plate to the lines until it has been swaged to the second die and accurately fitted to the cast at all points. After the plate has been properly adapted to the teeth and interspaces, anneal, and, after cutting away the portion that hooked over the front teeth, carefully fit it on the second die and lightly swage. Then examine the plate on the cast and see if it fits the die and cast alike. It is quite probable that at some points the die may have "dragged" slightly, which will be shown by a space under the plate at that point. Where this is noticed carve the die so that the plate fits both alike: this can be done very accurately by carving the die, placing the plate on it, and with a hammer making it fit the die at the point carved, and testing it on the cast, repeating this until they are both alike. The points needing special attention are around the teeth next the spaces to be supplied, the spaces between the teeth, and the edges of the plate. When this has been satisfactorily accomplished, go over the front part of the plate again, so as to make it fit against the natural teeth accurately, using this time the steel chaser, being careful that the tool is so held that it will carry the plate into place and not simply make an indentation in it or cut through it. This is an important operation, and should be done carefully and thoroughly. When it is done satisfactorily, swage the plate and file it accurately to the lines: in doing so let the upper edge extend a little over the lines in front, as it invariably sinks down a little in finishing.

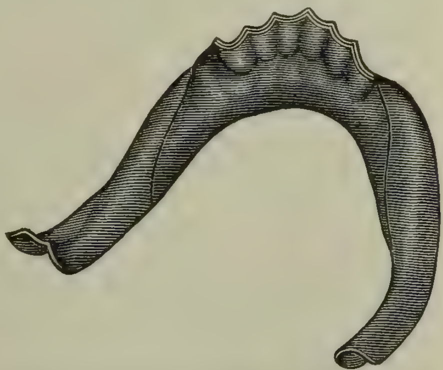
If the plate fits the cast accurately, we are now ready to make the "reinforcing piece," as it is called; that is, if we are satisfied that the cast is accurate. If there is the least doubt, it is best to try the plate in the mouth before strengthening, as it is extremely difficult to make any change in the fit of the plate after the reinforcing piece has been soldered on.

The reinforcing piece is added to give strength and stiffness to the plate at this point, which is weak on account of its shape, it being a near approach to a simple flat band, and on account of the strain it has to bear is liable to bend or break. It would hardly be practicable to make this form of plate heavy enough not to need reinforcing; to do so would make it unnecessarily heavy at all other points. The two plates soldered together are much stiffer than a single plate of the same thickness would be, and also make a neater finish. While the plate itself is made to fit into the spaces between the teeth, in swaging the extra piece the counter-die is cut away so as not to drive it into them; it bridges over the deep depressions which are filled with solder when it is united to the plate, making a smooth, easily-cleansed surface. The plate must be made very strong and stiff at this point, or it will be bent out of shape during the necessary handling in cleaning and placing in and taking out of the mouth; occasionally in a plate like Fig. 352 even a third thickness (which is usually added when soldering the teeth to the plate) is needed in the depression where the teeth and gums join; this does not extend the full width of the plate, as that would make the edges clumsy.

The reinforcing piece should extend as far as the natural teeth for the full width of the plate and taper off on each side, the lower edge extending, say, about half an inch farther than the upper edge, as shown by the dotted line at C, Fig. 350. This extra piece should be wide enough to extend at least one-sixteenth of an inch beyond the plate at its upper and lower edge for convenience in soldering.

Fit the reinforcing piece to the die (unless complicated it may be made entirely on the second die) and swage it separately from the plate. After trimming it to the desired size and shape, bevel the tapered ends from the upper or lingual surface to a thin edge, so that it will make a neat, smooth joint with the plate; clean the surfaces which are to be united and coat them with borax; place the plate and the reinforcing piece on the die in the position they are to occupy, and swage, placing thin paper on each side to prevent contact with the dies. Try the plate on the cast to see that the fit has not been changed; if found correct, place the two together, as shown in Fig. 374; lay them carefully on the soldering support, and unite them with a very small piece of solder at any point most convenient. It is desirable that the solder should not flow in, but simply unite the edges.

FIG. 374.



Partial Lower Plate, with reinforcing piece in position.

Allow it to cool (if chilled in water, the water, getting between the plates, may interfere with soldering), and lightly swage, using paper as before. Then place it on the soldering support, being careful to guard against any change in shape while it is heated, and flow a little solder as far from that just

fused as possible. We now have the extra piece united to the plate at two points, and with a little care the soldering can be completed without disturbing its position. I prefer this plan to clamps or to wiring, as they are so liable to bend the plate or to get out of place when most needed. Lay the plate on the support with the lower edge up, and so place it that the blowpipe flame can be directed against the extra piece. Place the solder, a little at a time, on the inside edge of the extra piece which stands above the plate, and so direct the flame that it will flow between the plates, and continue to add solder until it appears at the edges all round. If the depressions between the teeth have been very deep, leaving V-shaped spaces between the plates, place in them scraps of plate to fill them up. A little solder may be needed at the ends, but beyond this all the solder should be placed on the lower edge of the plate and made to flow between the plate and reinforcing piece.

After the plate has been cleansed from borax and the oxidation of soldering, file it accurately to the lines on the cast; it may require reswaging, but if the work has been carefully done it usually fits the cast. Some prefer to solder a half-round wire around the edges not covered by the double piece; this is arranged as previously described for a full plate. The plate is now ready for the clasps if they are to be added.

It has long been a favorite idea, especially with those whose laboratory experience has been limited, that dental plates could be made to conform more accurately to the dies by some method of stamping than by the usual method of swaging. I well remember when the "drop press" was occasionally seen in the dental laboratory, and since then various forms of screw presses for pressing dental plates into shape have been invented and re-invented from time to time.

More recently, Dr. Telschow of Berlin[1] has modified the hydraulic press, and M. Saussine, a dentist of Paris,[2] has devised a combination of a screw and an hydraulic press specially adapted to this purpose.

There is no question that a firm, steady, continuous pressure upon the dies is more effective in shaping a thin metal plate placed between them than repeated blows of a heavy hammer; this in the arts is an accepted fact, and metal stamping is exclusively done by machines exerting a force of this character. The difficulty of applying this method to the ordinary work of a dental laboratory arises chiefly from the practical impossibility of so constructing the dies that the pressure applied shall be evenly distributed upon the surface of the plate placed between them. In the arts, where the object is to duplicate rather than to perfectly fit a single plate, the dies can be so constructed and adapted to each other that the desired object is readily accomplished. In dental work the form, character, and method of making the dies and counter-dies render this exceedingly difficult: the time and labor required to fit them to the press would be far greater than any advantage derived from its use. In using the Telschow and Saussine press this may, in a measure, be overcome by constructing the dies in iron forms previously fitted to the press, as described in the article on Dies and Counter-dies.

Dr. Telschow first forms and partly swages the plate upon a zinc die in the usual manner, using the hydraulic press and special dies to com-

[1] *Revue odontologique*, 1881, p. 119. [2] *Ibid.*, 1883, p. 2.

plete the process. M. Saussine claims to be able upon his press to begin and complete the plate. He bends the plate with the fingers or with a pair of copper-faced pliers, so that it conforms somewhat to the die, before using the screw-press portion of the machine to bring the plate approximately into shape, and then, when the plate is nearly finished, and while the dies are pressed together as firmly as can be done with the screw, they are subjected to an hydraulic pressure which completes the operation.

I very much question the practical usefulness of either of these machines. In skilled hands they are able, no doubt, to accomplish all that is claimed for them: even then they will do no more than can be as readily accomplished by the skilful use of the hammer in swaging, while the process of making the dies and counter-dies for swaging is far simpler and more certain in its results than any method I have seen for making dies to use in a press. The press has but one decided advantage over swaging: it is almost noiseless in its operation.

Clasps.

For clasps we require an alloy possessing far more stiffness and elasticity than is necessary in a plate. An alloy of gold with about two grains of platinum to the pennyweight answers the purpose exceedingly well. For silver plates silver alloyed with either platinum or iridium has been used but to a limited extent in this country, although it is in general use in Europe. Either makes a desirable alloy, and one less expensive than gold, but with the usual appliances of a dental laboratory there seems to be difficulty in remelting the scraps so that they will be as tough as when the alloy was originally made; this no doubt has limited their use. Practically, considering the annoyance of having so many different alloys in use, the risk of accidentally mixing them, etc., I doubt whether it is not better to make all clasps of platinum-gold, an alloy readily procured and as readily worked as either gold or silver plate. Objection has been made to using gold clasps to silver plates on the ground of a supposed galvanic action between the two metals. I have constantly used them for many years, and have never had reason to suspect the slightest injury from that cause either to the patient's health or to the permanency of the work. I do not consider it necessary to have the alloy for clasps finer than eighteen carat, and would suggest making it by replacing with platinum two or three grains of the alloy in any favorite formula for plate. If the alloy contains much copper, less platinum is required; too much platinum inclines the alloy to brittleness.

The alloy is used for clasps in the form of plate and half-round wire. Half-round wire is used when the teeth are short, so as to obtain strength with a narrow clasp, and when, to avoid pressing upon the gum or to obtain a firmer hold upon the tooth, the clasp passes around the tooth in an irregular line; plate could be filed to the required shape in such cases, but not as readily as the wire can be bent. The peculiar shape of half-round wire permits its being bent in any direction; and on this account it can be more readily fitted to short molar teeth, and a

clasp made of it will often grasp them far more firmly than would one made of plate. The thickness either plate or wire should possess depends entirely upon the work required of it and the position it occupies. It should never be made so heavy as to be practically rigid: a clasp should always be, in a measure at least, elastic, so as to slightly give under severe strain, and thus ease the strain upon the tooth to which it is attached.

The strongest portion of all clasps should be where they are united to the plate, and from this point they should slightly taper to the free ends. A very common fault in making clasps is filing from the under edges where they pass around the proximal surfaces of the teeth, so as to keep them from pressing upon the gums, without at the same time so shaping the upper edge that the clasp shall be of uniform strength. The effect of this is to make a weak spot at a point where the clasp should be the strongest; all the bending takes place at this weak point, not only impairing its value as a clasp, but invariably causing it to break. If after relieving the lower edge the clasp is reduced in width toward the free end, so that the hollowed-out portion ceases to be the narrowest part of the clasp, its strength, usefulness, and durability would be very much increased. A properly-shaped clasp, opened out, would approximately resemble Fig. 376; one with the defect I have referred to is represented in Fig. 375. In each case the attachment to the plate extends from *a* to *b*.

FIG. 375. FIG. 376.

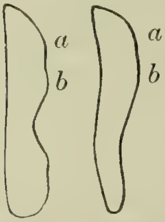


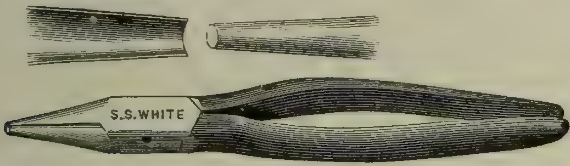
FIG. 375. Clasp weakened by filing from lower edge.
FIG. 376. Clasp properly shaped.

If the clasp must be narrower near the plate than at the free end, the narrow part should be made correspondingly thicker—not by soldering an extra piece upon it, but by making it of thicker plate, and filing the wider portions thinner, so that in proportion to the strain upon it it will be of uniform strength throughout, and as free to bend at one part as another. Before beginning to make a clasp carefully examine the shape of the tooth, its position in the mouth, and its relation to the plate, so as to form an idea of the direction and amount of force it will be required to sustain, and from this regulate its size, shape, position, and strength.

In making clasps fit them to the teeth before soldering only so far as is necessary to adjust them to their proper position—usually only the palatal and proximal surfaces, anterior and posterior—leaving that portion which is intended to pass around the buccal or labial surfaces straight. The object of this is, first, that they may not bind upon the teeth so tightly as to prevent them being readily removed from the cast without change when cemented to the plate prior to investing for soldering; and second, for the reason that in many cases they are more securely held by the investment when so made. The remaining portion of the clasps may be fitted proximately when the plate is adjusted to the mouth, but only so far as to lightly retain it in place, the final fitting being left until the case is entirely finished. If they are fitted so as to hold the plate firmly, it gives a great deal of extra trouble in adjusting the teeth, unless they are afterward bent to fit loosely again: the less bending a clasp receives the better.

In fitting a clasp we need a pair of round-nosed pliers, and also a pair of narrow-beaked flat pliers, with the inner edges of both blades rounded so as to remove the sharp square edge. (The clasp-bender, Fig. 377,

FIG. 377.



Clasp-bender.

designed for this purpose is an effective tool.) In some difficult cases it is necessary after fitting them with the pliers to swage them between dies: this is required when the surfaces to be fitted are rounding or the shape of the tooth very irregular. It is not often, however, that this is resorted to; it is frequently a difficult task, and not always as satisfactory as desired. In swaging there is a tendency to make the clasp fit accurately near the crown of the tooth while it is drawn away from the neck—a condition diametrically the reverse of that which is desired. There is also great difficulty in making the clasp retain its position between the dies. If it is placed in the counter-die first, and the die then placed in position, it will in swaging often be driven too far toward the grinding surface of the tooth; if placed on the die, it is driven down toward the gum. There is but little less risk of this if it is first soldered to the plate, with the additional disadvantages that no change can take place at the point where it is soldered, and if it is driven much out of position it will probably be necessary to remove it from the plate and resolder—if, indeed, it is not entirely ruined.

A skilled workman with the pliers and file, the occasional use of the small hammer and bench anvil, and in difficult cases a resort to the die, on which the clasp is fitted with the hammer, but not swaged, will accurately adapt clasps to teeth of very irregular shape, so that in practical laboratory work it is very seldom that clasps are swaged.

In fitting clasps to a simple case like Figs. 357 or 359, I prepare a strip of plate a little wider than the finished clasp is intended to be, so as to allow for filing the edge to fit the gum at the neck of the tooth, and also to allow for finishing and polishing the edge nearest the grinding surface of the tooth, and long enough for several clasps; in fact, a little longer, as it is quite difficult in practice, without wasting time, to make the first bend precisely in the right place, and it is always best to have a little margin for possible errors. Having the strip long makes it very much easier to handle. In case the lingual surface of the teeth are markedly "bulging," as is frequently the case with upper bicuspids and molars, a more accurately fitting and more effective clasp may be made by first curving the strip, making the side that fits against the tooth concave, so that it will fit over the bulging portion of the tooth. This may be done with the blade of the bench hammer, resting the strip upon a lead counter-die or on the anvil, but more conveniently by the lower plate-bender represented in Fig. 372.

In fitting clasps to the molar teeth, seen in Fig. 359, lay the strip flat against the anterior proximal surface of the tooth, allowing one end to project beyond the buccal surface as far as it is intended to pass around that corner of the tooth, and mark with a pencil or point or note with the eye the position of the first bend to be made in fitting the clasp to the palatal surface, and with the round- or narrow-beaked pliers or clasp-bender, as may be preferred, bend it, but at first not quite as far as necessary, so as to be able to correct any error made in the first bending without unduly straining the metal by bending it back again.[1] I use the narrow-beaked pliers almost exclusively for this work, as with them I can do all the bending necessary without changing the tool, while if the round-nosed pliers are used, they must be frequently changed for the flat pliers to straighten the curves, etc. Constantly changing tools unnecessarily wastes a great deal of time and detracts attention from the work in hand.

The clasp is now placed as nearly in position on the cast as its shape will allow, and note where it should be bent, so as to pass around the posterior proximal surface, and cautiously bend it into the required shape. Usually it will be necessary to file the lower edge of the clasp at certain points to allow it to fit well down to the gum at the neck of the tooth, especially on the palatal side; it is desirable to do this before the clasp is accurately fitted to the tooth, as it may somewhat change its position. This may now be done, at least so far as to allow the clasp to fit well down to the neck of the tooth, as it should do in the case we are considering.

When a tooth stands alone, as represented in Figs. 358 and 360, it is

[1] *Clasps as Fastenings for Artificial Teeth.*—"In the fitting of clasps several important points are to be considered: a good hold is to be gained, damage to the natural teeth avoided, and ease secured in applying, wearing, and removing the plate. These requisites are absent while the natural teeth retain their original form. If the clasps surrounding the teeth merely touch the centre of protuberance, the hold is slight and unstable, while the liability to injure is greatly increased by retention of extraneous deposits. Hence is shown the necessity for plane surfaces in the application of clasps. Proximal sides of all teeth which I intend to clasp are carefully and skilfully flattened with the file. My clasp-fitting is done entirely with pliers upon the teeth as they stand in the mouth, and my reliance is never upon any form of them which may be gained by impressions in plaster or wax. The part of a clasp first to be fitted should turn the posterior buccal corner of the tooth, passing along its proximal and flattened side to wind around its lingual swell, thence straight across its anterior face to a point just short of ocular perception. The turn at the place of beginning should be long enough to embrace the corner and enable the patient by catching it with his finger-nail to remove the plate from the mouth.

"Having adjusted the plate to the gums and the clasps to the teeth, our next effort must be to connect them. With the plate and clasps in position we proceed to take a try-plate impression. This may be obtained in plaster or wax: I prefer wax. For this purpose, if I have taken the original impression in wax, it is preserved in the pan until needed. This impression should be softened with warm water, inserted in the mouth, and pressed in place with a firm and even pressure. Withdraw carefully and without rocking. Remove the plate and clasps from the mouth, restore them to their impression in the wax, first, however, expanding them (the clasps) with the pliers to an easy fit upon the teeth—a fit so easy that you may put it on and take it off, and feel that it is without stricture and without friction. Having filled your impression with sand, plaster, and asbestos, and given an hour for setting, fasten your plate and clasps together with hard solder and try them in the mouth. If you have been faithful to my directions, you will know how much like true satisfaction a plate and clasps may be" (J. W. Clowes, D. D. S., New York, *Dental Cosmos*, vol. xxiii. (1881), p. 128).

a matter of but little moment on which side we make the clasp fit accurately first; but when it passes between teeth, after the clasp is roughly fitted make the portion between the teeth as accurate as possible, and then proceed to readjust the clasp from this point until it fits the tooth satisfactorily as far round as it is necessary that it should, before soldering it to the plate.

When the first clasp fits the proximal and palatal surfaces of the tooth neatly, before cutting it from the strip proceed in like manner to make the other, and then cut the strip in two. Invariably begin to make a clasp at the shortest end; when this end terminates between two teeth, but does not pass between them, especial care should be taken to make it pass into the interspaces as far as possible; it gives the clasp a much firmer hold upon the tooth. In clasping lower teeth, the upper cuspid teeth, and all teeth where the gum has receded, exposing the neck, the clasp should be made to fit the tooth at its largest part; the importance of this is self-evident. In some cases it is desirable to have the clasps so far above the line of the plate that it is necessary to connect them by a narrow strip of plate, forming what is known as a "standard clasp." This was originally designed as a means of preventing injury to the teeth by the presence of the clasp: in some cases two standards were used, or the clasp was soldered at two narrow points instead of one wide one, so as to promote cleanliness by not covering up so much of the tooth. This and various other devices to the same end have proved failures. In practice they afforded a lodgment-place for food, etc. quite difficult to cleanse, and in other respects have no advantages over clasps united to the plate in the usual way. There is a little knack in using the pliers, or where a short bend is to be made the hammer and anvil, in shaping a strip of metal into an accurately-fitting clasp, that can only be acquired by close attention and practice. Especial care is needed not to mar the teeth or break them from the cast: no matter how carefully a broken tooth is readjusted, it is not as sure a guide as it was before the injury.

In fitting half clasps or stay or collar clasps bear in mind the purpose for which they are used, so as to take advantage of every little point that may increase their usefulness. When two stay-clasps are used together on the same side—as, for instance, on two adjoining bicuspid teeth—file the ends that pass into the interspace thin, so that both clasps will pass well in, and avoid the common mistake of making one clasp short at this point. These clasps should fit very accurately at the neck: the teeth upon the model may be slightly scraped at this point before the clasps are adjusted, so that they will spring over the bulging portion of the teeth when placed in the mouth. Do not attempt to file the upper edge of the clasp into shape at this stage; that is always left until the plate is adjusted to the mouth.

As a rule, clasps for lower plates are not fitted close to the gum: the teeth are usually longer and more wedge-shaped than the upper teeth. To hold firmly, the clasp must embrace the tooth near the cutting edge: this is made necessary by the fact that the neck is so much smaller than the crown. It is frequently necessary to make little hooks or ears to catch over the grinding surface of lower bicuspids and molars in connection

with the clasps, to prevent the plates pressing too hard on the gums, as seen at A, Fig. 351. These may either be made with the file—which, where it can be done, is the best plan—or they may be soldered on after the clasp has been soldered to the plate and fitted to the mouth. It is always desirable to avoid using solder for any purpose on that part of a clasp which is intended to act as a spring, as it impairs its elasticity by making it rigid at that point. When clasps are applied to partial lower plates holding the posterior teeth only, especial care is needed in their construction to counteract the natural tendency in such plates to slide backward.

I do not deem it necessary to describe minutely the almost endless variety of clasps that different forms of plates require. The general construction is the same in all cases: first consider the object the clasp is designed to accomplish, and with this in view make it fit the tooth as accurately as possible.

When the clasps are fitted we proceed to adjust the plate to them. Place the clasps in position on the cast, one at a time, and file away the plate where it impinges upon them until it fits in place on the cast with all the clasps in place. The next step is to cement the plate and clasps together previous to investing for soldering. In ordinary cases the hard rosin-and-wax cement will be sufficient; for difficult cases shellac, being stronger and harder, is to be preferred. In using either it is best to first heat the plate and clasps quite hot and run a little of the cement upon them, otherwise the cement may not hold firmly. While the plate and clasps are accurately adjusted to each other on the cast unite them with the cement; allow a few moments for it to chill (plunging the cast in cold water will hasten this, but if any of the clasps should break off in removing the plate from the cast, more time will be lost in carefully drying it before the cement can be reapplied than is saved, so it may be considered a doubtful expedient), and then carefully remove the plate and clasps from the cast, being very watchful that their relative positions are not changed.

Occasionally we meet with cases where the clasped teeth occupy such a position that the plate cannot be removed without the cement breaking. In such cases use as much shellac as possible; let it get quite cold and hard before attempting to remove it, and allow it to break, afterward readjusting the plate and clasp off the cast, the fractured surfaces of the shellac furnishing a fairly trustworthy guide. It may be suggested that if the case cannot be removed from the cast it cannot be placed in the mouth. While this is true of extreme cases, we must remember that the teeth in the mouth are not so rigidly fixed as are their counterparts on the plaster cast.

After the plate and clasps are removed from the cast they are invested for soldering, either in plaster or a mixture of about four parts plaster to five of white sand, or the case may be laid upon the soldering support in a convenient position to reach the parts to be soldered with the blowpipe flame, and plaster mixed with water to a creamy consistency be placed upon and around it, so as to securely hold the clasps in position while the cement is being removed, and the clasps and plate are united by soldering. I much prefer to invest the case, the same as would be done

for soldering teeth, in plaster and sand mixed with water to a stiff paste, placing a suitable quantity on a glass plate, gently pressing the case into it as far as necessary, and building the plaster well over the ends of the clasps and the edges of the plate. This holds them far more securely, and permits their being heated up over a gas furnace or by other means to nearly the heat required for soldering. When plaster alone is used, as first described, there is danger of its cracking, or by contracting, as it always does when heated, drawing the clasps out of place; there is also a risk that the uneven heating of the plate may cause it to warp out of shape. This is all avoided by the second method. After the investment is hard remove the cement by chipping it off, which can readily be done with a cement suitable for this purpose, leaving the plate quite clean. Then scrape the plate and clasps, so as to make a clean bright surface where the solder is intended to flow, and then fill with plaster or whiting mixed with water to the consistency of cream the joint between the clasp and plate as far as it is intended to remain unsoldered. This is very important: if accidentally soldered too far, it is very difficult to undo the mischief; the attempt to saw it open is usually unsatisfactory: flowing whiting or plaster into the joint effectually prevents the solder from entering. Carefully coat with borax the points where the solder is to flow, and lay a small piece of plate over the joint, and on this the solder, just enough to unite them: more can be added after this has been fused; if too much is added at once, it is often difficult to manage. This applies not only to soldering clasps, but to all soldering operations.

If the case is on the soldering support, we may proceed at once to solder: first use a broad flame, and endeavor to heat the clasp and plate equally. As the heat approaches that required to fuse the solder, use a more pointed flame and concentrate it upon the parts to be soldered, but not directly upon the solder. If the solder is heated more than the plate, it melts into a ball, and is then more difficult to fuse. When in this condition more heat is required to make it flow, and sometimes the parts are made so hot that when it finally flows some of the surrounding plate is also fused with it. This is one reason why I recommend using a small piece at first. The solder always tends to flow to the hottest point: we take advantage of this in all soldering operations and direct its flow by the skilful application of the blowpipe flame. An iron or steel point in a suitable handle is a very useful assistant to replace or change the position of solder or to direct it while it is fused.

It is not important at this time to make a very strong union of the clasp to the plate; usually when the teeth are soldered all weak points are gone over and strengthened.

If the case has been invested in plaster and sand, the preliminary heating is usually done before the blowpipe is used, which simplifies the matter very much. When the soldering is complete, there is no objection to cooling the plate in water to save time. It is then "pickled" in acid and cleaned, either by rubbing with white sand and water with the fingers, or at the polishing-lathe with pulverized pumice-stone and a brush wheel. After this finish fitting the clasps, making the outer ends fit the teeth, and filing the upper edge to the size and shape

required, leaving, however, a little margin for any changes that may be necessary after the plate is adjusted to the mouth. After smoothing and rounding the edges with sandpaper, if the plate fits the cast accurately it is ready for adjustment in the mouth.

Trying in the Plate.

After the plate is finished on the cast, the next step is to adjust it in the mouth, not only to test the accuracy of the impression, but also to make any changes that may be required to secure a satisfactory fit. These changes may be necessary from slight inaccuracies of the cast or inaccuracies of workmanship, or from the character and condition of the mouth, and are more readily seen and corrected before than after the case is finished. An accurate impression gives the form of that portion of the mouth covered by the plate when the mouth is at rest, but gives scarcely an idea of how far the adjacent tissues encroach upon it during the natural movements of the mouth and associate parts. Neither does it note with any degree of certainty the character of the tissues it has been in contact with—whether they are soft and yielding or hard and rigid—whether they will bear pressure with impunity or are easily irritated. Some of these points may be noted when the impression is taken, and allowance be made for them in preparing the cast, but quite frequently they can be seen only when the plate is placed in the mouth. Hence the importance of trying in the plate.

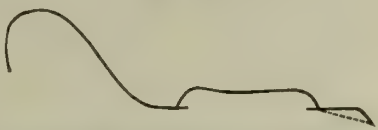
In a suction-plate, after relieving any points where it presses into the soft tissues, or in a partial case where it impinges upon any of the remaining teeth, test the fit in much the same way as it has been tested upon the cast: this should be done before testing the effectiveness of the vacuum-chamber. This is important. In many cases a moderately strong suction will hold the plate so firmly that a quite serious misfit may pass unnoticed, and the mortifying failure that results when the case is finished and its stability tested in the act of mastication will probably be incorrectly assigned to "warping during soldering."

Examine closely the back edge of the plate. In some mouths the centre is quite hard and rigid, while at either side the tissues are soft and yielding. It is recommended in such cases to cut away the cast while preparing it for making the dies, so that the edge of the plate will press harder on the softer portions, or to place a thin layer of wax on the cast over the rigid portion, so as to relieve the pressure at that point. Except in extreme cases I prefer to mutilate the cast as little as possible, and depend upon making the needed corrections when trying in the plate, believing it can be more accurately done at that time. Allowance must always be made for the changes the pressure of suction will make: a plate that fits quite loosely at this point may press uncomfortably hard after a few days' use. When it is necessary to make the plate press harder it may be bent with the pliers, or the cast may be cut away until there is the same space under the plate when placed upon it as there is in the mouth, and the plate bent up with gentle blows of the bench hammer: in either case do not bend the edge abruptly, as shown in an exaggerated form in Fig. 378, but let the bend be gradual, extend-

ing from an eighth to a quarter of an inch from the edge, as shown by the dotted line. If there is much difference between the fit of the plate on the cast and in the mouth, it is probably owing to a faulty impression, and the only remedy is to obtain a better one.

In some cases we may notice that the tissues on either side of the central hard ridge—or, where this is not well marked, along the entire back edge of the plate—are not only soft and yielding, but rise and fall with the movements of the mouth, although not forming any portion of the soft palate; nor does pressure in such cases always cause discomfort or nausea. If it can be done without impairing its stability, it is best under these circumstances to cut the plate away as far as this condition exists: when this cannot be done, and the parts are apparently not irritable, the edge of the plate may be bent up so as to secure, in a measure at least, a close fit at all times: it will often be tolerated with comfort and a firm suction be obtained. Occasionally it is necessary in these cases to "wire" the back edge of the plate to make it comfortable.

Fig. 378.



Posterior Edge of Plate bent to fit closely roof of mouth, showing also, in section, a Cleveland vacuum-cavity.

Where the central hard ridge is well marked and the plate presses hard upon it, it is sometimes necessary to reswage the plate with a thickness or two of paper between it and the die at this point, or an additional piece of plate may be soldered back of the chamber, it being placed upon and extending to the edge of the original plate, to allow for filing from this point if necessary after the case is finished; or sufficient relief may be obtained by placing a few thicknesses of paper under the plate on the plaster cast and gently striking each side alternately with the bench hammer, at the same time holding the plate firmly to the cast. If the undue pressure is at the extreme edge of the plate, it may be relieved with the pliers, but it is more frequently so far inside of the edge that they are not available. In a few cases we find an intolerance to the plate, its presence causing severe nausea even though it does not encroach upon the soft palate. Persistent use will often overcome this, but not always. Usually the centre of the mouth is more sensitive than are the condyles, and advantage may be taken of this to secure a more comfortable plate by extending it far back on either side and leaving the roof of the mouth free, or, in other words, making it "horseshoe"-shaped. In severe cases the trouble may generally be overcome by allowing the patient to wear the plate for a few weeks, removing from the back part a little at a time, as may be required, until it is tolerated and can be worn with comfort, when the case may be finished.

Occasionally the edges of the vacuum-chamber press too hard: this is easily relieved, and had better be left until the case is finished; it may be all right after the teeth are added.

Examine the edges of the plate all around and see that they are in close contact with the gums, and that there is sufficient room for the fræna during the various movements of the mouth; in partial cases see that the edges fit snugly against the remaining teeth. In partial cases,

when a vacuum is produced, see that the plate fits closely to the gum where it extends through the interdental spaces: it often happens that the pressure of suction slightly displaces the plate (usually bringing it forward): this more frequently happens with a small plate in which the vacuum-chamber is well in front; in some cases this movement is so marked that it is necessary to take an impression with the plate in place to obtain an accurate guide for arranging the teeth.

In full lower plates see that there is room for the frænum of the tongue when the tongue is raised as in swallowing, and that the back part of the plate does not encroach upon the cheek or interfere with the movements of the tongue. Lower plates are frequently made wide at the condyles, under the idea that the increased width adds to their stability and comfort. This is seldom the case; few mouths will tolerate a plate wider at the condyles than the face of the alveolar ridge.

In partial lower plates see that the plate fits closely to the teeth upon which it extends. I prefer to try in partial lower plates before the reinforcing piece is soldered on, so that any changes found necessary can be readily made; after the plate is "doubled" or "wired" it is very difficult to make any material change in its shape, on account of the stiffness imparted by the additional thickness and by the solder.

The clasps on all plates retained wholly or in part by clasps should be filed into shape and be bent around the teeth as far as they are intended to go at this stage, but should not be fitted closely to the teeth, except so far as they are intended to be soldered. To permit the ready removal of the plate from the mouth it is best to leave the clasps rather loose, especially if it is desired to adjust the teeth in the mouth before they are soldered to the plate.

In adjusting the clasps especial attention is needed to so shape the ends that they will hold firmly, and yet as far as possible be out of the way and out of sight, and at the same time be confined to those portions of the tooth least liable to injury. In bicuspid and cuspid teeth there is usually a more or less marked curve of the labial or buccal face, and frequently these teeth are markedly wedge-shaped. When this is the case, let the clasps be sufficiently wide on the proximal surface, that after the plate sinks down a little (as all plates do after they have been worn a short time) it will still embrace the widest part of the tooth, and the end that extends on the buccal or labial surface may be cut away from the upper edge so as to spring over the curve of that face of the tooth. This not only gives a firmer hold, but makes it far less conspicuous. In all cases, no matter how much the clasp may require to be cut away, either to avoid impinging upon the gum or from any other cause, be careful to so shape it that the strongest part shall be where it is soldered to the plate, and that it tapers off from this point to either end, as previously suggested.

In upper plates the clasps are designed mainly to hold the plate firmly to the roof of the mouth; in lower plates their chief function is to hold the plate in position, to counteract the tendency in these plates to slide backward, and also, where hooks or catches are added, to relieve the pressure upon the gum. They also hold the plate down, but this is usually their least important function. It is well to constantly bear

in mind this distinction between upper and lower clasps when making or adjusting them.

Usually the back edge of a clasped plate rests entirely upon soft tissue, it being so shaped to avoid the hard portions of the palate upon which a suction-plate rests; the edge may therefore be slightly turned up so as to press hard upon the roof of the mouth; and as the surface upon which it rests is usually irregular, this is best done by cutting a slight groove upon the cast before the dies are made and swaging the plate into it.

There are many minor points to be considered in trying in a plate that are so self-suggestive I have not deemed it necessary to refer to them, but have confined my remarks to those points less frequently noticed in the text-books, and which my experience has shown are more generally overlooked in actual practice. I have found it impossible to isolate any particular forms of plate, or even to distinctly classify them in describing their construction and adjustment. While each has its special points requiring close attention, they all have so much in common that the suggestions made in reference to a full upper plate, in a measure at least, apply to all forms of plates for either jaw. This is especially true in trying in a plate—an operation that cannot be done by rule, but requires the same close attention and judgment in every case.

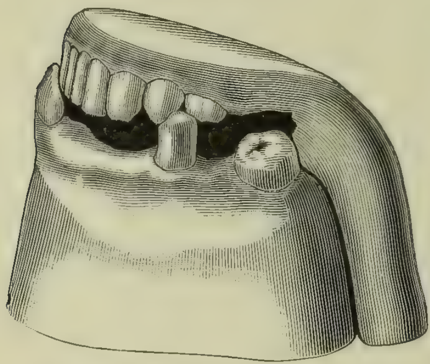
The Antagonizing Model.

We next proceed to obtain the articulation (or, in laboratory parlance, "the bite") or antagonizing model: the latter is by far the more expressive term. In partial cases this is quite a simple process, and is usually attended to at the time the impression is taken. With a little care accurate results can always be obtained.

First, examine the remaining teeth, and note the little facets worn by the opposing teeth; then ask the patient to close the jaws, and note the relative position of the teeth when the points that have produced the facets are in contact. Note also if the facets indicate any lateral or other motion in the jaws during mastication; if they do, allowance must be made for it when arranging the teeth. It is well to note on a slip of paper any peculiarities observed, and not to trust entirely to memory. Place in the vacant spaces sufficient slightly-softened wax to fill them and to take an imprint of the points of the opposing teeth (I much prefer wax for this purpose, except in a few cases where extreme accuracy is required, when I use plaster), or, if the spaces are close together, a roll of wax sufficiently large to include all may be placed in position and the patient be asked to close the teeth firmly. Notice particularly whether the teeth come together exactly the same as they did before the wax was placed between them. The patient naturally protrudes the lower jaw, or allows it to slide to either side when the presence of the wax is felt, so that it sometimes requires a little tact and repeated trials to obtain the desired result. Occasionally, by handing patients a mirror and explaining to them the position the teeth should occupy before placing the wax in place, we gain their assistance; but, as a rule, it is best to go about it quietly, and by means of conversation,

etc. lead their minds away from the task in hand. If the antagonizing impression is taken after the plate is made, it is best to have it in place in the mouth. When the teeth are properly and firmly closed allow a few moments for the wax to chill, and then remove it from the mouth and immediately place it upon the plaster cast. The wax is usually somewhat bent in removing it from the mouth, and if it is allowed to rest until quite cold it seldom goes quite into place. See that it is well in place: it is apt to not go as far down on the cast as it did in the mouth, and this, by making the articulation a little longer than desired, entails a great deal of extra work in fitting the case in the mouth after it is finished, besides marring the cutting edges by necessitating the grinding of the teeth shorter. Examine it by the mouth and note if the closure seems the same there as on the cast; if satisfactory, proceed to make the antagonizing model. For all partial cases, upper and lower, this should be made upon the cast, so that the teeth can be accurately fitted into position: a convenient form is shown in Fig. 379. It is made in the following manner: First build wax inside the cast, so that when the plaster is poured it will rest upon the back part of the cast and the cutting edges of the teeth only. This will prevent their being broken when the antagonizing model and cast are separated; build wax outside also to prevent the plaster running over. Then cut a V-shaped groove down the back part of the cast, and after oiling or otherwise preparing the plaster surfaces so that the new plaster will not unite with the old, pour plaster into the imprints of the teeth, and build it up on the back part of the cast, and sufficiently high above the tops of the teeth for strength, as shown in Fig. 379, but avoid making it unnecessarily large and clumsy. It may be trimmed into shape as soon as the plaster has set, reserving the finishing touches until it has become thoroughly hard and has been removed from the cast. The points of a good "bite" or antagonizing model are—first, it should give a correct idea of the manner in which the natural teeth come together; secondly, it should set solidly on the cast; and thirdly, it should be convenient to handle and present a neat appearance.

Fig. 379.



Antagonizing Model, partial upper denture.

Some prefer to take an impression of the opposing teeth in an impression-cup, and from this make a thin cast: having previously noticed how the teeth come together, this antagonizing model is simply held in place upon the cast. Occasionally this will answer, but it is seldom that the crowns of the teeth are taken so perfectly in either impression that they will come together accurately as they do in the mouth, and in any case it is far less easily handled than the antagonizing model previously described. These remarks apply to all the partial cases of either jaw.

In securing a correct articulation for a full upper or lower denture, or in a partial case where there are no natural teeth that meet, we have a much more difficult task. Many rules have been suggested and many methods devised to make this operation easier or more certain. I consider them of little value, and prefer to depend upon close observation and care. Study closely the patients' expression, especially when talking or when the mouth is at rest, and at times when their attention is not directed to the operation in hand, and endeavor to catch and fix in the mind their natural expression and the relative position of the jaws when that is secured. Much has been said and written in regard to restoring the natural contour of the face and the importance of closely following Nature in the size, shape, and arrangement of artificial teeth. I regard it as utterly impossible to restore by means of artificial dentures adapted to an edentulous mouth the same expression the individual had when the natural teeth were in place. There is a loss of tissue in the jaws themselves, and a change in the associate parts of the mouth in consequence of that loss, which cannot by any possibility be restored. This must necessarily change the expression. The arrangement of the teeth in many cases must be a compromise between that which is desired, and which the general arrangement of the natural teeth would suggest, and that which the form and peculiarities of the mouth and the conditions necessary to secure stability permit.

These points must be considered, and also the changes which naturally take place as age advances, so that we may safely say, as a rule, that a knowledge of the expression the patient had before the loss of the natural organs, or of their size or peculiar arrangement, would be of but little assistance in their replacement by artificial substitutes; in no case could they be put back again in the position they once occupied with satisfactory results. The temperament of the patient, where it is well marked, is suggestive both in regard to the general expression and the size, character, arrangement, and color of the teeth; but I prefer to rely upon no rules, but to closely study faces, so as to be able to appreciate what really constitutes a natural expression, and at the same time to keep in mind the mechanical principles involved in retaining an artificial denture in place, so as to know how far this natural expression can, practically, be secured. In all cases we may hope to so closely approximate the natural expression that after the patient and the tissues surrounding the teeth have become accustomed to and adapted themselves to the presence of the denture it will not attract a stranger's attention.

In securing the articulation for a full upper or lower denture, or for a partial case where there are no natural teeth that meet, proceed in the following manner: First, heat the plate so that it will adhere to it firmly; place upon it a roll of slightly-softened beeswax, sufficiently large to ensure that the opposing teeth will surely strike it; place this in the mouth and direct the patient to close the jaws. The wax should be sufficiently hard to prevent the patient's closing too far into it; it is desirable at this stage to only have a slight imprint of the points of the teeth in the wax as a guide in carving it into shape; and the wax should be both too full and too long; if not, add more until the desired length and fulness is secured. Then remove it from the mouth,

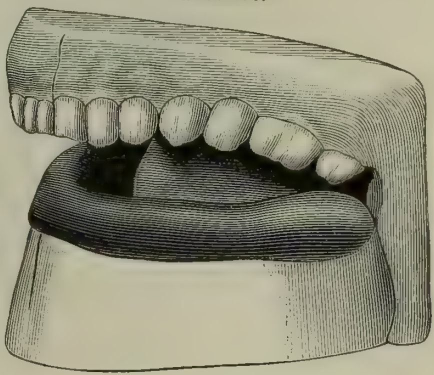
and with the imprint of the opposing teeth as a guide carve the wax somewhat to the size and shape desired for the teeth, leaving it only wide enough to give a fair impression of the points of the antagonizing teeth. Then replace it in the mouth, and direct the patient to close the jaws slowly, watching closely until they approximate the desired position. Again remove it from the mouth, and either add to or remove from the wax until on trial the desired fulness of lips and cheeks is secured. In upper dentures be careful not to make too much fulness immediately under the nose; as a rule, the plate, with the gums of the artificial teeth ground as thin as consistent with strength, will give quite sufficient fulness at this point; in many cases, indeed, too much. Considerable fulness in the gum is usually required over the cuspid teeth, not only to give expression to the mouth and reduce the objectionable wrinkle extending from the angle of the nose to the corner of the mouth on either side, but also to give a natural prominence to the cuspids and to give expression to the teeth themselves. The proper contour being secured, allow the patient to close the jaws until the desired length of "bite" is obtained. This must be decided by the general expression: we can only suggest that the lips should rest easily together without effort and without pouting. We may bear in mind that the teeth arranged by this wax guide will give rather less fulness on account of more ready movement of the lips over the smooth surface of the teeth, and that the length will appear slightly less, and also that after the teeth have been worn a short time they usually become slightly shorter and less prominent.

When both upper and lower teeth are required, proceed in the same way, placing wax on each plate, and after finding by trial approximately their relative position, trim off the surplus wax until that left on the plate represents as near as may be the intended teeth in length and general contour. It is important to trim the wax on the inside, so that it will not encroach unnecessarily upon the tongue; the less encumbrance the patient has in the mouth the more likely he will be to close the jaws naturally. If difficulty is experienced in securing the desired result, remove them from the mouth for a few minutes and endeavor to divert the patient's attention; let the jaws have a few minutes' rest, and try again. When satisfactory draw a line on the wax marking the centre of the face; let the line extend from the upper to the lower plate, and be sure to plainly and accurately mark it on both halves of the articulating model before removing the wax and plates from it. This line is not only a guide to the centre of the mouth, but also as to the "slant" of the teeth. With a knife make several cuts on each side, extending from the upper to the lower wax, to serve as guides in accurately placing them in position after removal from the mouth; then request the patient to raise the upper lip without opening the jaws, and mark on the wax its general outline, and also at the same time the outline of the lower lip. We find very few edentulous mouths that are "straight;" usually one side or the other droops, and when the mouth is opened the lip on one side is raised more than the other; this must be considered in arranging the teeth, and the lines last referred to are intended as guides to this.

I recommend that the centre and the outline of the lip be as carefully marked in taking the articulation for a full upper or lower or for a partial case for either jaw (unless these points are determined by the remaining natural teeth) as for a whole set. It has been recommended to fasten the two wax rims together in a whole set, before removing them from the mouth, by fusing them on each side with a heated instrument or by inserting wire staples. If care is used, this is unnecessary, and in many cases their removal from the mouth is facilitated by having them separate.

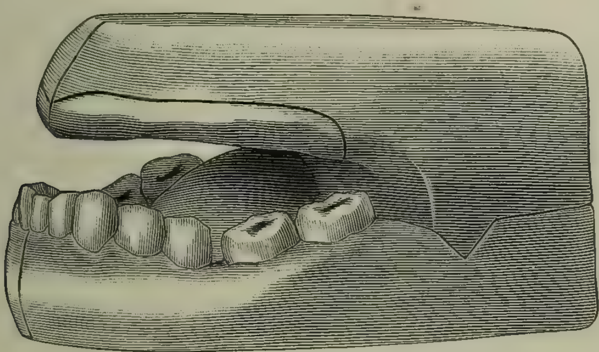
In making the articulating model for upper or lower dentures we usually have the choice of making it on the cast as recommended for partial cases (shown in Fig. 380), or making what is known as a "double bite" (shown in Fig. 381). In some cases, where the plate is cut away in front and plain teeth are used, or where gum-teeth are fitted directly on the gum, it is very important to fit them to the cast itself, and we therefore make the articulating model upon it. In other cases it is practically a matter of but little moment; in most cases it is less labor to make it on the cast, and if carefully and neatly done there is no objection to its being so made. In making it, first arrange wax on the inside, so as to prevent the plaster from filling the entire space; allow a projection of about one-half or three-quarters of an inch wide to rest upon the plate in an upper case and upon the cast in a lower case, extending it as far front as possible without interfering with the arrangement of the teeth. The object of this is to prevent the "bite" from tilting. The use of

FIG. 380.



Antagonizing Model, full upper denture.

FIG. 381.



Double Antagonizing Model, full upper denture.

rolls of paper instead of wax for this purpose, or allowing the plaster to entirely fill the space, the excess being afterward cut away, I consider careless and unworkmanlike. The articulating model for a whole set may be made in the same way, using the lower cast as the base.

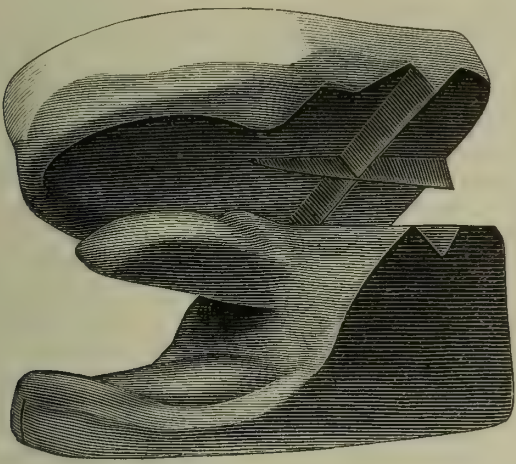
Occasionally it is desirable to use both casts in making the articulating model for a whole set: this makes a clumsy arrangement, and is best avoided where there is any choice. A "double bite" is rather neater and is more convenient to handle. It is made in the following manner (the manipulation in making one for an upper or lower denture or for a whole set differs so slightly that one description will answer): Prepare the articulating impression as previously described, so as to prevent the plaster from filling the entire space, and yet allowing a portion to extend well forward so as to secure stability. Then place this on the plaster bench, with the prints of the opposing teeth uppermost, or if it is for a whole set the lower jaw uppermost, and lay a piece of glass to receive the plaster that is to extend beyond the plate and form the body of the model. If the bite is a long one, it is best to raise the glass so as to make the two halves of the model of nearly the same thickness. Mix the plaster into a stiff batter and place it in position, being careful that it runs fully into all important points, and build it up with the spatula to the required size. This is readily done without the use of waxed cloth, pasteboard, etc. After the plaster is built to the desired size place upon it a piece of glass, and with gentle pressure level the upper surface, allowing the glass to remain until the plaster is set. The use of glass in this way saves a great deal of carving and gives the work a neater appearance. When the plaster is set remove the glass and trim the plaster to the required size and shape. Make it as small as consistent with strength and solidity, and be very careful to have it square with the plate and to have the plaster of the same thickness on both sides: if this is neglected it will probably make trouble in arranging the teeth, as the eye is guided in a great measure by the model in fixing the slant and curves of the teeth.

When this is done, cut two V-shaped grooves at right angles in that portion of plaster extending from the heel of the plate, and upon which the second part of the model will rest; these are intended as guides to cause the two sections of the model, when they are placed together, to always assume the same relative position. Oil the upper surface of the plaster, and proceed to make the second part of the model in the same way that the first was made. When this is hard trim to shape, mark the centre accurately upon both sections of the model, and then separate them. The portion of plaster extending upon the upper plate, or upon the cast in the case of a full lower denture, should be cut away, as shown at Fig. 382, so that the workman may see how the teeth articulate on their inner cusps.

There are in the market various patterns of articulators, or brass frames intended to represent as nearly as possible the human jaw, and designed to take the place of the plaster models just described. The part intended to represent the lower jaw is hinged to the upper one in about the same relative position as is the articulation of the natural jaw. They are so arranged that the casts can be readily attached to them by

means of plaster, or if desired the plaster can be run into the plates or into the antagonizing impression and the frames pressed into it while it is yet soft. Some are simple hinged frames, others more complicated and provided with various set-screws, by which the relative position of the upper and lower parts can be changed at will to correct any

FIG. 382.



Double Antagonizing Model, full set.

error made in taking the articulation, and with joints so arranged as to permit the various movements of the natural jaws. They are convenient for some purposes, and it is well to have one or two of the simpler patterns in the laboratory. When an articulating model is needed in a hurry or where great accuracy is not required they are useful. For general work they are not desirable. They are inconvenient to handle and are not sufficiently rigid. All I have examined spring sufficient to noticeably shorten the front teeth when grasped with the necessary force to hold them firmly. The various screws are not only liable to slip, and thus accidentally change the relative position of the parts, but are a constant temptation to meddlesome fingers. The idea that any error made while adjusting the case in the mouth can be corrected in an arrangement of this kind, however ingeniously constructed, is a fallacious one. I cannot see any practical advantage in being able to imitate the natural movements of the jaw in an antagonizing model. At best they can be followed but crudely. Could we remove the very jaws we are adapting the denture to, and use them as an articulator, it would be impossible to know with any degree of accuracy the relative positions they will assume when actuated by the muscles and nerves that belong to them: how much less possible is it with a model that only claims to *approximate* the average jaw, and is an exact counterpart of none!

Selecting the Teeth.

In selecting the teeth the first question to be decided is whether plain or gum teeth are to be used. In partial cases, if the roots remain or have been recently extracted, plain teeth are generally employed. Occasionally, however, where the roots are so far in the gum that plain teeth resting upon them would extend noticeably beyond the line of the remaining natural teeth, a tooth with a very short gum, or a tooth made in shape like a plain tooth with a little tip of gum, may be used to advantage. In some cases also a denture made immediately after the teeth have been extracted may require gum teeth, either to accommodate the articulation or where from the character of the gums a rapid absorption may be expected; in this latter case that part of the cast upon which the teeth rest should be cut away freely before the teeth are ground to fit it, so as to make them press upon the gums very firmly. The condition of the gums to which teeth are to be fitted and the position of the antagonizing teeth are to be carefully considered in deciding this question. If the natural gum is prominent, so that the addition of gums to the teeth would make the lips too full, or, as in some cases, where the lips (notably the upper one) are quite short, or where in laughing or talking the upper lip is raised unusually high, plain teeth made to press firmly into the natural gum—so hard, indeed, as to give pain when the denture is first inserted—will usually prove most satisfactory. On the other hand, the antagonizing teeth occasionally require the teeth to be set out as far as possible; as, for instance, in an upper denture where the opposing lower teeth are quite prominent, or in a lower denture where the upper teeth close considerably beyond the lower ones. In either of these cases, although otherwise plain teeth would be preferable, the thickness and length of the gum are required to avoid the unnatural leaning in or out unavoidable in such cases when plain teeth are used, or to allow room for the antagonizing teeth to properly close. In upper dentures, to avoid making the lips too prominent, plain teeth are frequently used for the incisors or the incisors and cuspid and one or both bicuspids of each side, the plate being cut away so as to allow them to be set upon the natural gum, the case being completed with gum teeth.

If the lip is very long, so that there is no danger of the plate being seen above the teeth, plain teeth may be used and made to fit to the plate, which in this case should extend over the alveolar border. In partial cases where the gum has receded from the remaining teeth plain teeth usually look best, especially if suitable ones can be found so shaped as to represent the exposed upper portion of the root. When they can be used to look well plain teeth are most desirable. They are not only more readily arranged, but the little irregularities which add so much to the natural appearance of a denture are more easily and neatly made with plain than with gum teeth. In lower dentures plain teeth, or teeth long in the tooth part and with short gums, usually have a more natural appearance, especially if the patient is advanced in years.

In selecting teeth we have also to consider their shape, size, color, and character. In partial cases endeavor to accurately match the remaining

natural teeth, which can generally be done from the almost endless variety found at the dental dépôts. It is impossible to give specific directions for selecting teeth: the dentist should cultivate the faculty of seeing and remembering the main points and peculiarities of the case in hand; he should know, at least in a general way, the style and character of the various moulds of artificial teeth obtainable, and make himself familiar with the more marked peculiarities of the natural teeth and their relative importance. It would be a positive disfigurement to place a perfectly flat central in a mouth where the remaining natural teeth were markedly curved, while in a mouth where the remaining teeth were decidedly fan-shaped to use a straight central in order that its width at the neck may more effectually cover an unsightly root would scarcely be noticed. In color a tooth too light or too blue is far more conspicuous than if the error is of a more neutral or a warmer tone.

The points to be especially noticed are as follows:

First, shape: Whether the sides of the tooth are nearly parallel or divergent—*i. e.* whether the tooth is straight or fan-shaped.

Second, size: Not only the width and length, but also the *relative* width and length of the centrals, laterals, and cuspid teeth.

Third, character: Flat or curved, whether curved transversely or from gum to edge, or both; whether thin, translucent, and delicate of form, or thick, dense, and massive.

Fourth, peculiarities: This may include the presence or absence of transverse or longitudinal grooves or lines; the character of the cutting edge, whether straight or rounded on one or both corners; whether the tooth is symmetrical or curved more on the posterior than the anterior edge.

Fifth, the shade: If the natural tooth cannot be accurately matched, note toward which color or tone the error will be least noticeable; also, whether the adjoining teeth are vital or dead—whether they retain their natural appearance, or whether it has been changed by decay or by filling. It is always best, when the space requires a single tooth, to select several and match them in the mouth; two teeth may closely resemble each other, yet one may look far better in the mouth than the other.

Select teeth as nearly as possible the size required; if they are too large, the fault may, to a certain extent, be corrected by the grindstone, but if much is removed the natural appearance of the tooth is usually marred; this is especially the case if much is cut away from the sides or the cutting edges.

The position of the pins should also be noticed. They usually have two (in very large or very long teeth three or four), arranged either transversely or perpendicularly, and technically known respectively as cross and straight pins. Cross-pin teeth should be avoided wherever possible; they are weak from the following reasons: First, the position of the pins weakens the tooth at the point where it is most liable to break; second, when arranged in place both pins are brought near the plate, making the strain upon them greater on account of the increased leverage between the pins and the cutting edges; third, this strain stretches the platinum of which the pins are made, and this permits a slight rocking motion which

soon breaks them off. It is a common error to always select cross-pin teeth for a close bite. In all such cases the backings should be extended to near the cutting edges, so that they will relieve the teeth of part of the strain. When this is done there is no advantage whatever in cross pins. This position of the pins is occasionally useful, however, when the teeth are very short and wide.

The straight-pin teeth are more reliable, mainly from the fact that the upper pin is closer to the point at which the force is applied, and the leverage upon it is therefore less: there are other points, but they are of minor importance and self-suggestive.

The position of the pins is also varied. Some are nearer the cutting edge than others; some are placed nearer together than others, so that, knowing this, with a little care in selecting, teeth may be obtained with the pins in the best position to resist the strain of constant use.

In selecting teeth for full dentures we may, in a measure, disregard the teeth that have been lost, and select those of the size, shade, and character that look best and harmonize best with their intended surroundings. Nature sometimes makes as serious an error in fitting a mouth with teeth as the dentist does in replacing them.

The width of the front teeth is determined mainly by the position of the cuspid teeth: they (the cuspids) form the abutments of the arch made by the six anterior teeth, and should occupy the full width of the jaw, so as to partially hide the posterior teeth. In determining the width consider also whether they will look best close together or with spaces between them. The width of the posterior teeth is not a matter of so much moment: as a rule, I think they are made too narrow. It is best to have them close together, so as to prevent the lodgment of food.

Consider also the relative length of the upper and lower teeth. When the tongue is large and the jaws small, it is best to select thin posterior teeth, especially for the lower jaw.

Arranging the Teeth.

We now come to the really artistic work in constructing an artificial denture, and yet it is not wholly artistic, for we must always consider the mechanical conditions involved in its construction and use.

Beyond the proper use of the mechanical means employed, it is very difficult to give definite instruction in regard to arranging artificial teeth. The artistic skill, if there is any shown, must emanate from the workman himself, and is acquired and cultivated by a close study of Nature's own work. It has been suggested that a collection of models from impressions of the natural teeth, each accompanied by a well-matched porcelain tooth or teeth giving the color of teeth and gums, and also a statement giving the age, sex, physical characteristics of the face, and temperament of the patient, etc., would be a valuable guide in selecting and arranging artificial teeth. I much prefer to study the peculiarities of articulation and expression from the living model, and to cultivate the faculty of appreciating harmony and detecting discord in the relation of the teeth to the individual, rather than burden the mind with a mass

of confusing detail and encumbering the workroom with a practically useless collection of casts. Such a collection might be useful in illustrating to students the various points to be considered, but if used by a practical workman they, while suggesting but little, would be apt to lead to an objectionable mannerism and formality.

Artistic skill is especially required in arranging the anterior teeth in whole or in full upper or lower or in partial dentures. Where the anterior teeth are all absent, their relative length, the fulness, and curve are at least suggested by the articulating model and by the wax used in taking the articulation, which should always be preserved intact until after the teeth are adjusted to the plate. The spaces between the teeth, the relative length of the individual teeth, the "slant"—that is, the angle at which they stand to each other and to the median line—and those little changes in position imitating the irregularities of the natural teeth, are matters which depend mainly upon the workman's judgment, and in which his artistic skill is largely shown.

The posterior teeth are less conspicuous and the mechanical requirements more exacting, but still there are artistic points in their arrangement which I shall presently consider.

In partial cases where the teeth are scattered we have simply to imitate as closely as possible the adjoining or corresponding natural teeth, and to make the new ones harmonize with those that remain.

In partial cases where the roots remain the outer edge should be cut away about one-sixteenth of an inch below the level of the gum, the inner edge not quite so much, and the surface be made level and smooth, before the impression is taken, so that the gum-tissue will well cover the joint between the root and the artificial tooth. We may bear in mind in this connection that the gum nearly always recedes slightly after the plate is inserted, and that the root should therefore be cut away sufficiently to allow for it. This should always be done immediately before the impression is taken, and the impression obtained before the gum covers the root, so that the impression of the root will be clear and sharp. It is quite important that the tooth should be made to fit the root neatly, which can readily be done if we have a good cast to work on, and care is taken not to injure that portion representing the end of the root to which the tooth is to be fitted. If this is imperfectly represented upon the cast, or if it is marred or injured while making the plate, etc., securing a satisfactory fit between the tooth and the root will prove a difficult task. Occasionally, when the root is much decayed or out of position, it is desirable to let the tooth rest upon the gum; in such cases every care should be taken to thoroughly hide the root and leave as little vacancy in which food, etc. may accumulate as possible. In a few cases where the root is badly decayed, and where a plain tooth would be required much longer than the adjoining teeth, a tooth with a short gum may look better than a plain tooth, the gum tip reducing the apparent length. In setting plain teeth where the roots have been extracted, let them press well into the gums, cutting or scraping the plaster cast at the points where the teeth are to rest, so as to secure a relative lengthening of their necks and a corresponding increase of pressure upon the natural gum: if they press too hard when the case is finished, a touch

of the grindstone will correct it. The same precautions are required in setting gum teeth: it is very desirable that the natural and artificial gums should nicely blend and that they should fit closely.

Always bear in mind that, as a rule, there is a slight shrinkage of the gum under the pressure of the plate: if the teeth are made to fit closely to the gum without pressure, while they may look well at first, in many cases within a few weeks this shrinkage will leave an objectionable space, making it necessary to cut the tooth off and to reset it. This shrinkage will vary in different mouths; where the gum-tissue is soft and yielding, or where the teeth have been recently extracted, the cast may be cut away freely and the teeth be thus made to press quite hard against the gum; if necessary it is very easy to relieve this pressure after the case is finished. When the gum is hard and unyielding, or when the teeth have been absent a long time, the cast must be trimmed more cautiously.

We may also remember that this portion of the cast, especially the labial surface of the gum and that immediately adjoining the remaining natural teeth, is apt to be reproduced a trifle larger than it is in the mouth, even though the cast is from an otherwise faultless impression. This may be owing, where plaster is used, to the manner in which the plaster flows through the interspace, or may be due to neglect in not pressing the plaster to the gum, or the plaster may be drawn away from the gum by the lip before it is set, or in removing the impression this portion may break away in such a manner as to prevent accurate replacement. The defect frequently occurs, and while it is generally slight it is, unless corrected, sufficient to make a decided misfit between the natural and artificial gum. When wax or other plastic material is used for the impression, accuracy at this point cannot be looked for.

It is better for the operator to trim this portion of the cast when trying in the plate: the condition of the natural gum and the relative position of that portion of the plate passing between the teeth on the cast and in the mouth will suggest the changes necessary. An experienced workman may from the appearance of the cast judge with considerable certainty the probable condition of the gum and the accuracy of that portion of the model, but is far more liable to err than the operator with the mouth before him. I call especial attention to these points, as my observation leads me to think that the appearance, if not the usefulness, of many partial dentures would be improved were they more generally considered; and also because a laboratory experience of many years, working upon casts from impressions made from various impression-materials and by many operators, has demonstrated that, practically, an absolutely perfect cast is rarely if ever seen.

In all partial cases where the teeth rest partly upon the plate and partly upon the gum I prefer to first adjust to the cast, without the plate, all the teeth that stand alone or adjoin the natural teeth, leaving them a trifle long; I then place the plate upon the cast, and first file away the edges, so that while the teeth shall have a solid bearing upon the plate its edges are completely covered. As the exact position of each tooth is now known, this can be done quickly and accurately. I find, as a rule, that plates are cut away far too much; they should be filed

to a thin edge and be allowed to extend well under the tooth. This holds the teeth more firmly and solidly, and in a measure relieves the strain upon the pins, and after the case is soldered the thin edge is readily burnished up to the teeth, making a neater finish and a more cleanly denture. In cases where plain teeth resting upon the natural gums are used while bevelling the edge of the plate do not cut it into festoons, but leave the edge smooth and even; the plate between the teeth can be cut away with a small fine-cut half-round or oval file as much as may be necessary after the teeth are soldered, and far more neatly than it can be done while arranging them in place. Having first adjusted the teeth to the cast, we have only to grind away sufficient to allow for the presence of the plate: this simplifies matters very much, and enables the workman to make a better fit in less time.

The object in leaving the teeth a trifle long is to secure a solid bearing on the plate. It frequently happens while arranging a tooth that before it is well in position a portion is ground away that we afterward find was removed unnecessarily; this in practice is often unavoidable, and if no provision is made to correct it an objectionable space is left under the tooth. If the tooth is left a trifle long while fitting it to the cast and plate, this space is readily obliterated by shortening it after its position is definitely determined.

In roughly grinding a tooth we depend mostly upon the eye to know where to apply the stone. After it is partly in place a slight movement of the tooth will leave a white mark where it rests upon the cast, and a dark one where it rests upon the plate. In very difficult cases the parts to be fitted may be coated with a little rouge and oil or other like coloring matter. This is seldom needed, however, and to a practised workman is of far less value than might be supposed: it is uncleanly, must be repeatedly applied, and covers up many little points that otherwise are readily seen.

In grinding the teeth we have not only to fit the cast and bite, but also to observe carefully the probable position of the opposing teeth during the functions of speech and mastication; to observe carefully the alignment not only of the cutting edges, but also of the junction of the teeth and gums; and also to allow for any probable change in the parts upon which the plate rests, due to the pressure of mastication, absorption, etc., that may change the position of the plate. As a rule, we may safely leave all teeth a trifle long, to allow for sinking up of the plate after a few weeks' wear, and while fitting the teeth try to see them on the cast, with "the mind's eye," as they will be after this change has taken place.

I always prefer to try partial cases in the mouth with the teeth partly fitted, and, noting the changes needed, afterward complete by arranging them in place on the cast. It is seldom necessary to try them in the mouth a second time. In exceptionally difficult cases it may be best to complete the arrangement by the mouth. A few notes or lines on the cast made with a lead-pencil, indicating desired changes in length, slant, etc., made immediately after trying the case in, will greatly aid the memory.

In fitting gum teeth that stand alone or adjoin natural teeth be

careful that the artificial gum does not extend nearer the cutting edge than does the gum of the natural teeth, and also see that it is not too wide to pass between the teeth when the plate is placed in the mouth.

In cases where the teeth on each side of the space lean toward each other, making the space much wider at the gum than at the cutting edges, much care and skill is required to neatly fill the space and yet permit the denture to be placed in the mouth. In some cases it is best to so arrange the plate and teeth that they can be placed in position by a side movement without passing over the cutting edges of the natural teeth. It is difficult to describe how this may be done, as each case requires different treatment: a careful study of the case, however, will usually suggest the method.

We frequently meet with cases where the interspaces, from changes in the normal position of the teeth, are either too wide or too narrow for the teeth that should occupy them. If the space requires several teeth, a slight change in the width of each or the addition of an extra tooth or leaving one off, as the judgment dictates, will usually overcome the difficulty. If there is only one to be supplied, and that an anterior tooth, it is a much more difficult task. If the space is too narrow, the tooth may be placed slightly irregularly; this not only permits of a wider tooth, but prevents the defect—*i. e.* the difference in width between the artificial and the corresponding natural tooth—from being so readily seen. If the widest tooth that can be got into the space is much narrower than the corresponding one, select a wider tooth and neatly bevel the sides, so that it will slightly overlap one or both of the adjoining teeth. Sometimes one method will look best or best suit the antagonism of the opposing teeth, and sometimes the other. If the space is too wide and will not admit of an additional tooth, select a tooth as wide as will look well and arrange it to slant or lean forward a great deal, and correspondingly change the shape of the cutting edge. In this way we may succeed in so filling the space that it is not unsightly while using a tooth so nearly the width of the remaining ones as not to attract attention. A careful study of cases of irregularity, and of others where there has been a departure from the normal arrangement, will suggest many little ideas that may be profitably used in overcoming the difficulties that constantly perplex the operator.

In adjusting the posterior teeth in partial cases we have far less to consider; if seen at all, it is only by a side view, and if arranged so as not to be conspicuous the artistic requirements are usually satisfied. As a rule, they should stand slightly, very slightly, inside the line of the natural teeth, providing that the natural teeth are in their normal position. Occasionally this rule must be violated to accommodate the articulation or to hide a filling or a defective tooth. Sometimes it is necessary to make the artificial teeth longer or shorter than the adjoining natural teeth, in order that they may properly antagonize the opposing teeth. In these cases this defect may often be made less unsightly by shortening the outer cusps or by leaving them longer than the inner ones, without materially impairing their usefulness. In extreme cases the bicuspids or molars may be replaced by cuspid teeth,

or sometimes a central incisor tooth may do better in place of a molar, a metal step upon which the opposing teeth may strike being built up inside the backing while the case is being soldered. Considerable artistic skill may be shown in shaping the buccal cusps of the bicuspid teeth; removing the extreme point or changing its shape, etc. often adds very much to the appearance of the denture. I recommend that these changes be made after the denture is finished and adjusted to the mouth, or, preferably, after it has been worn a few days or a week.

Whenever possible, endeavor in filling spaces to make the teeth fit tightly at the cutting edges, so as to prevent the packing of food between the natural and artificial teeth. This is not only a source of discomfort, but may cause the plate to be displaced. In order to do this it is permissible in most cases, if necessary, to use a bicuspid in place of a molar or a molar in place of a bicuspid. In all cases endeavor to secure solid contact with antagonizing teeth, being especially careful to make the inner or lingual cusps strike quite as hard as the buccal cusps. When this is neglected, not only is the patient deprived of a portion of the masticating surface, but the pressure upon the buccal cusp alone seriously impairs the stability of the plate.

In full upper or lower or in entire dentures I prefer to first arrange the eight anterior teeth roughly, only grinding them sufficiently to approximate the desired position, and leaving the spaces between the teeth quite wide. This enables us to fix the position of the bicuspids and to determine accurately the space to be occupied by the six anterior teeth. We can also see whether the teeth lean properly, and make any necessary changes before grinding them accurately. If there is any doubt about the centre of the mouth being accurately marked on the cast, hold the case so that a line drawn through the centre antero-posteriorly is exactly perpendicular: if the central teeth are in their proper positions, the bicuspids will be directly opposite to each other. There are occasional exceptions to this rule, but it is so generally reliable that it is well to regard with suspicion any centre mark that does not conform to it, and to carefully examine the mouth to see that it is correct before grinding the teeth, so that their position cannot be changed without injury.

As a rule, in full upper or lower cases the centrals are adjusted first, then the laterals, the cuspids, and the first bicuspids; by arranging them in pairs when roughly placing them in position, and also when adjusting them finally, we have a better idea of the general effect. After the first bicuspids are in place this ceases to be important. In these cases the position of the teeth and their length are mainly determined by the articulating model. In whole dentures, if the operator has carefully carved the wax used in "taking the bite," this may be considered a rough guide in determining the relative length and the position of the cutting edges of the teeth, but even with this help much depends upon the workman's judgment. It has been suggested to use either the upper or lower wax and adjust one denture at a time; that is, if the upper wax is used secure it to the upper plate and proceed to arrange the lower teeth to it as though the lower denture alone was being made. After the lower teeth are all in position remove the wax

from the upper plate, and proceed to adjust the upper teeth to the lower ones. It is supposed that by this method the fulness and relative length as indicated by the wax are correctly reproduced in the teeth. In practice this is seldom the case; more frequently it leads to errors of arrangement and articulation very difficult, if not impossible, of correction. I find it far better to remove the wax, and, keeping it in sight as a guide, adjust the teeth by the eye. A good workman finds no difficulty in thus fully carrying out the operator's desires as expressed by the wax, and can always secure a much more harmonious arrangement by fitting the teeth to each other in the manner about to be described. In fact, practically, carefully carving the wax to the desired fulness while taking the articulation is of far more assistance in securing the correct length of bite than in indicating the arrangement of the teeth. As a rule, the form of the mouth and the relative position of the jaws as shown by the articulating model suggest more to an experienced workman in regard to the required fulness than the wax itself. In exceptional cases written or verbal directions should accompany the case, or the teeth may be tried in the mouth when roughly arranged, and needed changes noted, so as to avoid the necessity of making alterations after they are accurately fitted to the plate.

As a rule, in entire dentures the lower anterior teeth should stand straight—that is, lean neither in nor out—and should be a little longer than the upper ones. The relative length of the upper and lower teeth must be regulated by the relative length of the upper and lower lips; it is a safe rule to make the upper teeth barely long enough for the tips to show when the mouth is open without raising the lips, and to make the lower teeth meet them. Always bear in mind that any addition to the length of the upper teeth impairs the stability of the plate, while an increase of length to the lower teeth affects their stability but slightly, if at all.

I prefer in arranging an entire denture to first roughly adjust the lower centrals and laterals, then the upper centrals, and follow with the lower cuspids, the upper lateral, the lower first bicuspid, and the upper cuspids and first bicuspids. Do not attempt to close the spaces between the teeth to any extent until the bicuspids of each side are roughly in place. Spacing the front teeth enables us to correctly articulate the posterior teeth; if the lower teeth should prove too wide or too narrow for the upper ones, we can correct this by making the spaces wider or narrower. The relative width of the upper and lower teeth at times cannot be seen until the bicuspids are in place. A disproportion in width is not always an error of manufacture or selection; the position the teeth occupy has much to do with it: where it is not very great a little care in spacing will correct it perfectly.

After the anterior teeth are roughly in place there are several points that require careful and critical attention before proceeding to their final adjustment.

First: The Centre.—It is important that the median line of the face should exactly divide the space between both the upper and the lower centrals for their entire length. Cases are not unfrequently seen where this is neglected, the centre perhaps being right at the cutting edges, but

the teeth slanting either to the right or to the left. Sometimes this is seen only in the upper, sometimes in the lower denture, and sometimes in both. Sometimes the teeth so slant that a line drawn through the space between the centrals is not parallel with the median line of the face, or the centre of the lower teeth does not correspond with the centre of the upper teeth. These errors affect the appearance of the denture far more, and are more plainly seen in the mouth, than an error in the position of the centre itself: they should be carefully avoided.

Second: The Slant.—The centrals of each side should lean slightly toward each other; in fact, all the teeth, especially those of the upper jaw, should lean slightly toward the median line, the laterals as much as the centrals—in some cases a little more—the cuspids not as much, and the bicuspids and molars very little. In slanting the teeth there is room for judgment and artistic taste. Little variations in the slant, judiciously made, give the teeth a natural appearance, taking away that "picket-fence look" so often and so justly complained of. As a rule, the lower teeth should slant but very little, if at all, yet, while they usually stand nearly straight, there is opportunity for little artistic touches in slightly slanting the cuspids toward or from the median line, or giving the teeth an appearance of crowding so frequently seen in nature, or in any way breaking the unnatural regularity so often observable in artificial teeth, without at the same time making the irregularity so glaring as to especially attract attention. These irregularities, especially the more noticeable ones, are not to be made haphazard in every case, but only when they will harmonize with the patient's general expression, or where they existed, or are supposed to have existed, in the natural teeth.

Third: The Lap.—The anterior teeth of a full denture should lap but slightly. If the cutting edges pass each other sufficiently to prevent lisping, that is all that is required. If the lap is too great, the stability of the upper denture is impaired without any corresponding advantage. It is a safe rule not to let the cutting edges of the anterior teeth quite touch upon the articulating model, as invariably when the denture is placed in the mouth the lower jaw moves slightly forward, and so changes its position that the lap is a little more in the mouth than on the model. It is desirable that when the denture is in the mouth the pressure of mastication should be entirely upon the posterior teeth, and that the anterior teeth should not be in absolute contact.

Fourth: Relative Length.—The relative length of the anterior teeth is either shown by the articulating wax or arranged according to instructions received with the case. The relative length of the posterior teeth is usually left to the workman's judgment. It has been recommended to let the articulating edges of the lower posterior teeth curve downward; that is, to make the lower second bicuspid and the first molar a trifle shorter than the first bicuspid and the second molar—a condition we frequently find in nature. It is claimed that by so doing the lower plate is held in place better and is less liable to be thrown forward during mastication. I consider it of doubtful advantage. If there is considerable mobility of the lower jaw, if there has been difficulty

experienced in taking the articulation, owing to the patient's showing a disposition to throw the lower jaw out or to either side, it is better to have the cutting edges of all the teeth on the same plane, and to so arrange them that if either denture is placed upon a level surface all the teeth will touch ; and also in such cases round the points of both the upper and lower bicuspids, so that the teeth will come together properly with the jaws in any position they are likely to assume in mastication or in speech. If this is not done, the points of these teeth, striking during the movements of the jaw, will displace either or both dentures. The same difficulty will be experienced with a mobile jaw if the line of closure is curved : unless the jaws come together exactly as they are represented on the model by which the teeth have been arranged, the articulation will be uneven and the plates liable to be displaced.

All the advantages of the curve can be secured without any of its disadvantages by so adjusting the relative length of the upper and lower posterior teeth that as they are pressed together there will be a slight tendency to press the lower plate backward. This is accomplished by making the line of closure not quite level, but a trifle higher at the back part of the mouth. It is well to note the position of this line when taking the articulation, as it cannot always be determined by the model.

I have frequently noticed that although the teeth articulate nicely and evenly while being examined in the mouth, yet, owing to some peculiar movement of the jaw, the last molars have struck so hard when the teeth have been in actual use as to displace the plates. On this account I recommend making the last molars articulate only on their anterior cusps, leaving a space of, say, a sixteenth of an inch between the posterior cusps. This may be accomplished by allowing them to slant back slightly or by rounding off the posterior cusps.

Always remember that giving additional length to the lower teeth and reducing the length of the upper teeth favor stability.

Fifth: Expression.—A great deal is comprised under this term. In many mouths a slight change in the position of the teeth alters very greatly the expression of the lips. A careful study of the face, especially in profile, with all the natural teeth in position and the lips at rest, will give valuable hints in regard to the arrangement of artificial teeth in this particular.

I find, as a rule, that when the lips are at rest with the mouth closed the upper lip projects slightly beyond the lower one. We will also find that, as a rule, the lower lip is more prominent at its upper edge than where it joins the chin. This will suggest the importance of arranging the anterior lower teeth so as to have but slight fulness at the gum, and to let them stand straight or slightly leaning outward in nearly all cases. It is seldom necessary to set them so as to lean in, and rarely that they give a good expression when so arranged. Even when the lower jaw projects, unless the projection is excessive it is better to set the lower teeth straight or perpendicular, and to allow the upper teeth to lean out to meet them. Sometimes in these cases it is admissible to give the gums of the upper teeth considerable fulness, especially at the cuspid teeth. Fulness of the upper gum immediately under the nose should

always be avoided: it is rarely needed at this point, and usually not only gives the upper lip an appearance of being swollen, but also destroys the effect of fulness at the cuspids. In profile the upper and lower teeth when closed should show a marked outward curve, so as to give prominence and expression to the lips and to allow freedom to the tongue during speech. The lower posterior teeth should stand well on the alveolar ridge, and be nearly perpendicular, or if there is considerable difference in size between the upper and lower jaws, they may lean in very slightly. Always be careful to allow plenty of room for the tongue: to this end the molars should be narrow on the masticating surfaces, and not be allowed to lean in so much that the plate will be displaced by the tongue when it is raised to the roof of the mouth. When the ridge is very narrow care and judgment are required to select suitable teeth and in so arranging them, that while the tongue is allowed all possible freedom they are so placed that the force of mastication will tend rather to press the plate more firmly to the gum than to displace it. An intelligent study of the case will show how this can be done far better than the necessary arrangement can be described. Allowing them to lean either in or out to any great degree should be avoided whenever practicable.

The position of the upper posterior teeth is in a measure fixed by that of the lower ones. The first bicuspid should articulate between the first and second lower bicuspids, and the natural arrangement of each tooth articulating with two of the opposing teeth be followed as closely as possible. The advantage of not closing the spaces when roughly arranging the teeth is now seen in the facility it gives of securing a proper articulation by making them wide or narrow as may be required. The first upper bicuspid should set in so as to be partially hidden by the cuspid tooth when the denture is in place in the mouth. The upper posterior teeth should project but very slightly over the lower ones, except when the mucous membrane of the cheek is quite dense and lies closely to the teeth: in such cases it is well to allow the upper teeth to project a little, so as to prevent the patient from biting the cheek. Let the teeth set well on the ridge, and avoid as much as possible any leaning out; if the cutting edges must be out to meet the lower teeth, it is better to set them out bodily rather than to allow them to lean to any great extent.

It sometimes happens, owing to the relative shape of the upper and lower jaws, that the upper last molar cannot be made to cover the corresponding lower molar, unless either the lower one is set in more than is desired or the upper one is set out: in such cases it is usually best to keep both teeth in the position that suits them best, and sacrifice a little mastication-surface.

In general contour the anterior teeth should form a rather flattened arch and occupy the full width of the jaw: the posterior teeth on each side, beginning with the first bicuspids, set slightly inside the cuspids, should form straight lines, diverging as they extend backward. The object should be, first, to bring the six anterior teeth boldly in view; second, to so place the posterior teeth that while they are seen they occupy, expressionally, a subordinate position, as they always do in a well-formed natural denture. Always avoid the error so generally

made of including the bicuspids in the arch: the arch should be formed exclusively by the six anterior teeth; and also avoid the error of allowing the molars to curve inward, giving the denture a "horseshoe" shape. The teeth, as usually made, naturally fall into this peculiar form, owing to their shape, they being made narrower on the back. The gum teeth are so shaped to save labor in jointing.

I frequently see both errors exemplified in the same denture, the bicuspids of each side set out as far as the cuspids, and the last molar set in more than the first molars: this not only destroys the natural expression and shows at a glance that they are artificial, but also impairs their usefulness by encroaching upon the tongue and interfering with its free use in speech and mastication.

It is very rarely indeed that the posterior teeth perform the same office in giving expression to the cheek that the anterior teeth do for the lips, except so far as the fulness of the cheeks is changed by the distance the jaws are held apart, so that in arranging them we may consider the stability and usefulness of the plates the most important consideration. When much fulness is desired, it is usually obtained by forming what are known as "plumpers"—at best a clumsy device, and rarely required except to correct the loss of tissue caused by surgical treatment or by the ravages of disease.

The expressional value of the cuspid teeth must not be overlooked. When gum teeth are used the gums of the upper cuspid teeth may be left quite prominent when needful to modify and make less sharp the wrinkle extending from the angles of the nose to a little beyond the corner of the mouth. It has been recommended to extend the upper plate quite high at this point with this object in view, but it is seldom this can be done to advantage in plate work; in fact, I question its value in any but exceptional cases.

While there are many points of expressional value common to all cases, and many that are suggested to a skilled workman by the models submitted to him, there are so many of great importance that can only be seen when the teeth are in place in the mouth that I prefer in all cases to examine the denture in the mouth before the teeth are fully arranged, and to note the changes necessary to make them harmonize with the general features of the patient, and to replace, expressionally, as nearly as practicable, the natural organs.

Sixth: The Articulation.—First, the articulation as affecting speech. So space the anterior upper and lower teeth that the point of the upper cuspid will come exactly between the lower cuspid and first bicuspid, or a little more forward, and so arrange the teeth that there will be no space through which the air will escape in speaking. Unless care is taken there is apt to be an opening either between the upper cuspid and lateral or between the upper cuspid and first bicuspid, which if neglected is liable to cause a whistling or hissing sound in speaking, equally annoying to the speaker and noticeable to the listener. The triangular shape of the cutting edge of the upper cuspid leaves a corresponding space between it and the lateral into which the point of the lower cuspid is intended to fit. From various causes—the difference in shape and size of the upper and lower jaws, or their relative position, or from

the lower incisors being either too wide or too narrow for the upper ones—it is at times difficult to place the teeth in their intended position. These spaces may be closed by bringing the teeth into their proper position while closing the spaces between them, or by slightly lengthening the upper cuspid, or by changing the shape of the cutting edge of the lower cuspid or first bicuspid or upper cuspid. It is desirable, however, if possible, to avoid taking from the cutting edges at this stage.

Secondly, the articulation as affecting mastication. To fully understand the points involved in articulating the posterior teeth I recommend a careful study of the various movements of the lower jaw in connection with the forces brought in play during mastication and speech, the direction in which they impinge upon the teeth, and the extent and manner in which they affect the stability of the plate. If this is once mastered and the knowledge acquired intelligently used, it will save many annoying failures. The movements of the tongue, the lips, the cheeks, etc. are all to be considered in this connection; for although they do not directly affect the articulation of the teeth, they limit to a great degree the positions in which the teeth can be placed. For instance, to make the posterior lower teeth lean in would increase very much the stability of the denture if the forces of mastication were alone considered; but if this were done the necessary movements of the tongue would displace it, so that there is often a marked difference between the best position and the best *practicable* position of the teeth.

It is important that the inner cusps should strike as hard as the outer or buccal cusps. This is a point often neglected. We may remember that the buccal cusps are usually outside of the point of support, the centre of the alveolar ridge, and therefore even a perpendicular force would tend to displace the denture, while the same force exerted upon the inner cusps, which are inside the point of support, would tend to press it more firmly in place. It is frequently necessary to use the grindstone upon the cusps in fitting the molar teeth in place: in doing so take off as little as possible, and only when absolutely necessary. If the grinding surfaces of the molars are made flat and smooth, their value as masticating organs is seriously impaired. When this has been done it is better to restore the roughness by grinding several grooves across the tooth from side to side, and one from back to front, with a thin corundum disk. I usually prefer to have the greatest pressure of mastication upon the second bicuspids and the first molars, and to make the second molar a trifle short.

A cement composed of yellow beeswax and rosin or gum dammar is generally used to hold the teeth on the plate while arranging and adjusting them in the mouth. The gum dammar makes a more translucent cement, but is more costly and has no practical advantage over rosin, which answers every purpose. The proportions vary with the season: as a basis two parts of rosin to one of wax may be given, but in summer much more rosin or dammar is required than in winter. To prepare the cement, melt the rosin or gum dammar in a suitable vessel, and add wax until test pieces of the cement are when thoroughly chilled but slightly brittle. The cement is then poured into a vessel of cold water, and when cooled, but still plastic, is worked into sticks about the size of

a pipestem. These are allowed to become quite cold, and are then dusted with dry plaster to prevent their sticking together, and packed away for use. After the edges of the plate have been filed away and properly bevelled, preparatory to adjusting the teeth, heat the plate a little more than is sufficient to melt the cement, and thinly coat with it those portions of the plate that will be covered by the cement required to hold the teeth in place. Unless the plate is thus prepared a cement hard enough to be conveniently handled will not adhere to the plate with sufficient firmness to hold the teeth securely in position. The presence of moisture upon the plate or teeth will also prevent adhesion.

In partial cases where there are only one or two teeth together they may be ground to position and be held in place with the fingers, while a stick of cement is melted over a spirit lamp or a small Bunsen gas-burner in the same way that sealing-wax is used, and dropped on to the tooth and plate so as to hold them together. This is made to hold more firmly by heating the wax spatula quite hot and holding it in the cement, not only melting it, but also heating both the plate and tooth. When this is set, more cement is added until there is sufficient to hold the tooth or teeth firmly, the wax spatula being used to shape and smooth the surface. In some cases where a tooth stands alone, shellac, on account of its strength, is preferred. It holds much more firmly, but has the disadvantage of being so hard that no change can be made without first softening it with a hot instrument: as it is very brittle, a slight strain or jar will break the tooth from the plate. The resin-and-wax cement will readily permit slight changes, especially after it has been in the mouth a few minutes.

When a number of teeth are together or in a full set it is usual to place a roll of cement on the plate before beginning to arrange the teeth. The teeth, slightly warmed, are pressed into this, and are held sufficiently firm: the object is to have them so held in place that their relation to the models and to each other may be determined, and yet to permit of their ready removal and replacement. For this purpose use as little cement as possible; if too much is used, it is very much in the way and prevents many little points being readily seen. After the teeth are satisfactorily in place they are secured by "running" or melting the cement with the heated wax spatula, and adding more cement if needed. While grinding the bicuspids and molars I prefer to have that part of the plate to which they are to be fitted quite free from cement, so as to see under and all around the teeth, and to have nothing in the way of fitting them solidly and accurately to the plate. After each tooth is arranged in position it is held with a few drops of cement. It is best to first firmly cement the anterior teeth, then each side as soon as the teeth are satisfactorily in place, using the cement neatly, yet, if they are to be tried in the mouth, having sufficient to hold the teeth firmly.

Jointing of gum teeth—that is, fitting the gum portions of gum teeth to each other—is usually done, or at least completed, after the teeth have been fitted to their proper position. If there is much material to be removed, it may be roughly done before this, but it is impossible to tell accurately where to grind until the tooth is well in place. Thus in grinding, say, the first bicuspid, it is fitted in place, and that side of the

gum adjoining the cuspid is ground so as to fit it accurately and allow the teeth to come as close together as is desired, and then fastened in place with cement The posterior side of the gum is not ground at this time, unless it is seen either that there is a large surplus or that it will require but little grinding : if it only requires the edge to be made smooth, it is done at once. In the first instance sufficient is removed from the first bicuspid to allow the second bicuspid to approximate nearly as close as desired, and yet leave sufficient tooth-substance to make a good joint if the gum-edges of the two teeth are not quite parallel. It is then cemented in place, and after the second bicuspid is arranged it is removed and the joint completed by removing from either tooth as the judgment directs. Ordinarily, it is advisable to remove equally from each, but in some cases, notably the joint between the cuspid and first bicuspid of the upper jaw, advantage may be taken of the slight rounding of the edge of the gum to secure a better joint by removing largely from one tooth. It is desirable that the first upper bicuspid should set in a little more than the cuspid ; this would leave an offset on the gum if we removed equally from each, as but few sets of teeth are made to permit this ; but by simply smoothing the edge of the cuspid gum, and removing from the bicuspid all that is needed to close the space between them, we are enabled to set the tooth part in as far as desired and yet avoid any offset at the gum, the gum being a little thicker a line or two from the edge. Advantage is taken of this also where the surface to which the gum is to be fitted is irregular, or where we desire to place the teeth irregularly to give them a more natural expression. Occasionally the appearance of the denture may be improved by slight touches to the gum portion with a thin corundum disk. For instance, when the patient is advanced in years, and where the gums of the natural teeth, were they present, would have been found somewhat receded, taking a little from the gums so as to reduce or shorten the point of gum extending between the teeth toward the cutting edge, if neatly done, gives them a far more natural expression. Slight offsets on the gum, at times unavoidable, either on the face of the gum or the point we have just referred to, extending farther on one tooth than the other, may be rounded or removed with decided advantage. These artistic touches must be done neatly, carefully, and with judgment. Any little changes of this character require the removal of the tooth after it is fitted in place, and for this reason the teeth are not securely cemented to the plate until the fitting is entirely completed.

The teeth are usually made with the gums wider on the front (the labial or buccal surface) than on the back (the lingual or palatal surface), so that when two are placed together in the position they are to occupy, with the front edges of the gums in contact, the back edges are more or less apart, leaving a V-shaped space between them. Always endeavor to close this space and fit the gum part of the tooth as close at the back as at the front. If this is not done, there is danger of the front edge chipping during soldering ; then, too, the space between the teeth, forming a receptacle for food, etc. that is very difficult to clean, will be a constant annoyance in the finished piece of work. It may be partly closed when preparing the case for soldering by filling with foil or small

pieces of plate, but it is one of those defects far easier to avoid than to remedy.

In jointing, some prefer to hold the edge of the gum to the side of a perfectly flat stone, and good work is done in this way. Unless great care is used, however, the natural tendency is to allow the gum to rest solidly against the stone instead of only removing from the edge, as is usually required, and thus make them fit only at the edges, leaving the V-shaped spaces just referred too. Others prefer a stone about half an inch thick, with a flat edge and of large diameter—say, from four to six inches—and kept exclusively for this work. This, in a measure, is liable to the same faults: the tooth must be held very accurately and steadily. I much prefer to use for this purpose the edge of the stone ordinarily employed, and produce the even, smooth surface by moving the tooth across its face in the same way that a long knife is ground upon a narrow stone; it is far easier to see what is being done, and to remove those portions requiring removal without encroaching upon those parts that we desire shall remain.

In cases where it is desired to have as little fulness as possible the gum teeth may be set directly upon the natural gum, the plate being cut away to allow them to do so. It is seldom necessary to cut it away farther back than the cuspid teeth. Always allow the plate to extend as far under the teeth as possible, and bevel the edge of the plate quite thin, so that after the teeth are soldered it can be burnished up to them and made a close joint. I frequently see the plate cut away far too much, not only depriving the teeth of the support it should give, but impairing the suction and bringing the edge so directly under the solder that it is too stiff to burnish up to the teeth. In these cases special care should be taken in grinding the teeth to make them fit closely to the plate and to press hard upon the natural gum, the model being scraped or cut away to permit them to do so.

In cases where the upper lip is so short that the edge of the plate is liable to show above the gums of the teeth, and where fulness of the gum is required, cut away the plate so that the gums of the teeth will just cover it, so fitting the teeth that the edges of their gums rest upon the natural gums.

Plain teeth are more readily arranged than gum teeth. Where they are set upon the plate they should be ground to fit solidly, leaving no spaces under them for the retention of food, etc. Usually, where they are used the six or eight anterior teeth are set upon the natural gum, the plate being cut away to permit it. In order to ascertain where to cut the plate, first arrange the teeth to the cast without the plate; while doing so carve the cast so that the teeth shall press hard into the gum. This is an important matter, as has already been explained. The beauty of plain teeth thus adjusted consists in so arranging them that they appear to be growing out of the gum. When as many of the teeth as are to set upon the gum are in place and cemented upon the cast, go round the necks of the teeth where they rest upon the gum with a fine needle-point, making a traced line upon the cast representing the position of the teeth. Remove the teeth and cut the plate so that the edge shall be about a sixteenth of an inch within the line, not following the

festoons, however, but making the edge straight and thin. The triangular portion of plate between the teeth can be readily and neatly cut away with a fine file while finishing the case. Then replace the teeth, grinding them to fit over the plate. In grinding plain teeth it is better to have a much smaller stone than for grinding gum teeth.

After the teeth are satisfactorily arranged try them in the mouth before proceeding further: before doing so see that they are firmly cemented to the plate, using the wax spatula to run the cement well around the pins and make the surface of the cement smooth and even.

Trying the Teeth in the Mouth.

Trying partial cases in the mouth is frequently a difficult task, especially if the teeth are scattered. If a hard cement is used, it is necessarily brittle, and the teeth are broken from the plate with the slightest strain; if the cement is soft, they will move, and unless carefully watched and their position in the mouth compared with their position upon the model, the trying in will amount to but little. Quite frequently the teeth fit so tightly between the remaining natural teeth, or are placed at such an angle, that the plate cannot be removed from the mouth without displacing them. In these cases I endeavor to judge of the changes necessary, and adjust the teeth by the model after the plate is removed from the mouth. It is not always best to arrange the teeth so that they can be readily placed in the mouth while fastened on the plate simply with cement: it may be a decided advantage to make them fit rather tightly. Or, again, the natural teeth may so lean that, although it is quite difficult to pass over them the plate with the teeth attached with cement, the finished case, with the plate and teeth firmly united by solder, will readily spring into place, and be held more securely and comfortably than if made to go into place easily.

When either plain or gum teeth are made to press hard upon the natural gum, the cement usually gives way and they are displaced when placed in the mouth, so that it is necessary to place them upon the model and readjust them before investing.

Theoretically, it seems a very plausible plan to place the case in the mouth, make the needful changes, carefully remove, and place it at once in the investment; but practically, except in simple cases involving only one or two teeth, the final result is invariably disappointing.

The main point in trying teeth in the mouth is to see that they are expressionally correctly arranged, and to detect and correct any defects in the cast and articulating model. The mere mechanical details of fitting close to the gum, etc. are readily arranged on the cast. It is well to bear in mind that if the teeth fit too closely a touch of the grindstone will correct the maladjustment; if not close enough a partial remaking of the case may be necessary.

Some little defects may be noticed when trying the teeth in the mouth that can be better corrected after the case is finished. For instance, a little change may be necessary in the shape of a cutting edge or a slight improvement in the articulation, etc. may be required; but as there may be slight alterations in the position of the teeth during soldering, these

changes can be more safely effected after the case is finished. It is sufficient in these cases to make sure that the necessary changes can then be made. Particular attention should be given to the length of the teeth, their articulation, and their correspondence or harmony with the remaining natural teeth.

In full upper or lower or entire dentures the points to be carefully considered are—first, the accuracy of the articulating model: if that is correct the teeth should articulate in the mouth very nearly as they do upon it; second, the expression and the changes in articulation and expression due to the movements of the mouth and adjacent parts, and their general harmony. (The reader is referred also to the suggestions made when treating upon "taking the articulation" and "arranging the teeth;" they are equally appropriate here.) Trifling changes in the articulation that can be made with the grindstone may be left until the case is finished; some changes that may seem necessary at this time may not be needed when the patient can close the mouth firmly without danger of displacing the teeth from the plate.

If the articulation should prove defective or the teeth be found too long or too short, it is better to place a little soft wax between the teeth on each side of an entire denture or all around an upper or lower denture, and proceed to take a new articulation, allowing the teeth to remain upon the plate if they do not interfere with the new bite, as their presence aids in the correction of the defects of the old articulation. Make also a new antagonizing model: this course is far more satisfactory than to attempt to alter the old one, and always saves time in the end.

The arrangement of the teeth in the mouth is perhaps the only operation in the making of an artificial denture in which we may safely seek suggestions from the patient and the patient's friends: such suggestions are at times valuable, but must be accepted and acted upon with tact and judgment.

When the arrangement of the teeth is satisfactory to the operator and the patient, the next step is to secure them in some suitable material, so that their relation to the plate may be preserved during the process of backing and soldering: this is termed "investing."

Investing.

All cases of plain teeth, and partial cases of gum teeth where they stand alone or where not more than two or three are together, usually need no preparation for investing beyond seeing that the teeth are held so securely by the cement that there is no danger of their displacement when the denture is imbedded in the investment; but in cases where the gums are very long and are not supported by the plate, or have been ground very thin, it is a wise precaution to place a drop of yellow wax inside the weak gums, so as to prevent the plaster from coming into actual contact with them, and thus lessen the risk of their being broken when the case is removed from the investment after soldering.

In cases where there are a number of gum teeth together, with the gums closely jointed, some provision must be made to prevent accident from their expansion when heated for soldering. If this is not done

there is serious risk of chipping at the edges where they are jointed together, or the teeth may be broken so as to require replacement. The usual point of fracture from this cause is, first, horizontally, about where the tooth and gum joins; or second, vertically, the face of the tooth splitting off. This fracture divides the tooth at about the heads of the pins, and is frequently assigned, incorrectly, to defective manufacture or to expansion of the platinum pins. This form of fracture is more frequently seen in the back teeth, but is not confined to them. There is also, when the gum portions of the teeth are too closely jointed, risk of the plate warping during soldering: where in lower dentures this occurs the plate usually curves inward, the condyles being brought nearer together; in upper dentures the change in shape makes the plate press upon the hard palate, producing what is known as a "side rock."

To prevent these accidents take a strip of thin soft paper (the margin of a newspaper answers the purpose if it is not too thick), and, beginning at the centrals, remove, one at a time, each alternate tooth, and place in the joint between the gums a thickness of paper, removing from the tooth with the grindstone sufficient to allow for it. The object is to place a thickness of paper between the gum portions of the several teeth, and thus prevent actual contact between them. If carefully done the space made is so slight as to be unnoticed, while it effectually prevents the accident referred too. To remove the tooth, pass the hot wax spatula by the side of the pins to soften the cement around them, and then push it off. If this is done carefully the cement is left so that the tooth can be accurately replaced, an application of the wax spatula securing it in place again. I find it better to do this alternately, first on one side and then on the other, beginning at the centrals, in preference to beginning at one end and passing around the arch, which involves more risk of materially changing the position of the teeth. When heated for soldering the paper burns out before the heat is sufficient to expand the porcelain to any great degree. It is necessary to get the case very hot, so as to burn the paper out and leave the joints clean: if this is not done it is simply charred, leaving the joints black and unsightly, and the only remedy is to reinvest the case and heat it to a higher temperature.

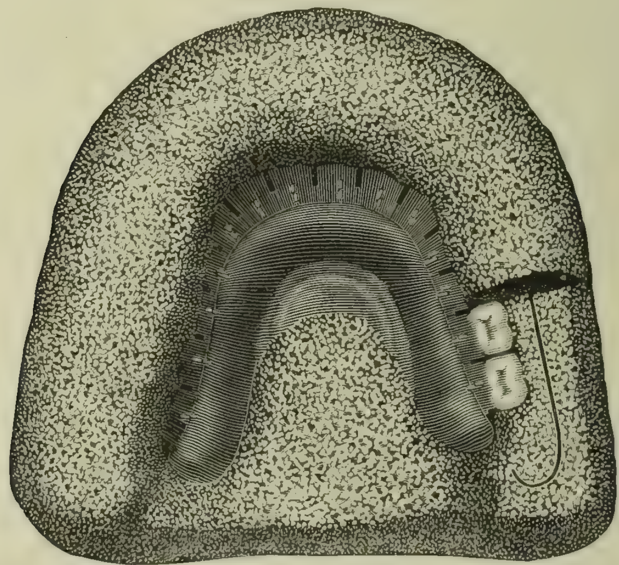
The investing material is composed of about five parts of white beach sand to four of plaster of Paris. Adding about a teaspoonful of pulverized asbestos to the quantity used in investing a case is thought to make it stronger and less liable to burn away from the teeth during soldering. The sand should be thoroughly mixed with the plaster, and water should be added to make it of the right consistency. Ordinarily, it should be quite stiff, sufficiently so to be readily built up to and around the teeth. In some delicate partial cases it is better to have it rather thin, placing a mass of the investment upon a piece of glass and then carefully laying the case upon it, working it down with a gentle rocking motion until there is rather less than half an inch under the deepest part of the plate: after this has become somewhat set add more of the investment, building it up to and around the teeth. In less delicate cases it may be mixed stiffer, a mass placed upon the glass, and after first filling up the deeper portions of the plate, it may be pressed into the

investment, which with the fingers or a spatula is built well up to the teeth, the fingers or the spatula being wet, so as to make the plaster work more kindly. In all cases of more than a few teeth a piece of copper or iron wire about one-eighth inch thick, bent to the form of the teeth, with a hook at each end, should be placed in the investment outside of and about one-fourth inch from the teeth, and a little below the cutting edges (shown at A, Fig. 384). The object of this is to hold the investment together in case it should crack in heating or soldering.

The points to be borne in mind in investing a case are—first, to be sure that the material is in contact with the under surface of the plate at all points, especially that it fills the bands or clasps of partial cases: if there are any vacancies, there is danger of the plate being overheated and burned at that point, or of sinking in and thus impairing the fit; secondly, to see that the teeth are well covered, not only to hold them securely, but also to protect them from the direct contact of the blowpipe flame; and thirdly, to see that the edges of the plate are also covered: if this is neglected, they are apt to curl up. It is desirable that the surface of the plate should be well exposed; if it is covered up too much, there may be difficulty in getting it hot enough in soldering.

After the investment is hard, cut away sufficient to expose the cement and proceed to pick it away with a sharp point. The cement should be

Fig. 383.



Upper Denture invested and ready for making the backings, and showing position of wire to guard against fracture.

hard enough to chip away readily, leaving the teeth and plate quite clean. The use of dry heat or of hot water for this purpose is very objectionable, and is never required if proper cement is used. After this is removed trim the investment, cutting away from the inside, so that the

teeth can be readily reached in making the backings and by the blowpipe flame in soldering. Always avoid exposing the cutting edges of the teeth more than is needful, not only on account of the risk of their displacement, but also because of the greater risk of shattering the edges by an accidental touch of the blowpipe flame. Carve the outside neatly, so as to be convenient to handle. In lower dentures the investment is cut away from the inside, as in Fig. 384, to allow the blowpipe flame access to the plate. I prefer to have the investment quite thick —about half an inch under the plate, and from a half to three-quarters of an inch around the teeth. I have not found the increased thickness to cause the plates to warp, as some contend it does. If sufficient sand is used, if the joints of gum teeth are free and the plate well swaged, there will be very little trouble with plates warping during soldering unless they are made very much too hot. Figs. 383 and 384

FIG. 384.

Lower Denture invested and ready for making the backings: A, position of wire to guard against fracture.

show upper and lower denture investments, a portion of each being cut away to show the thickness of the investing material and the position of the wire previously referred to.

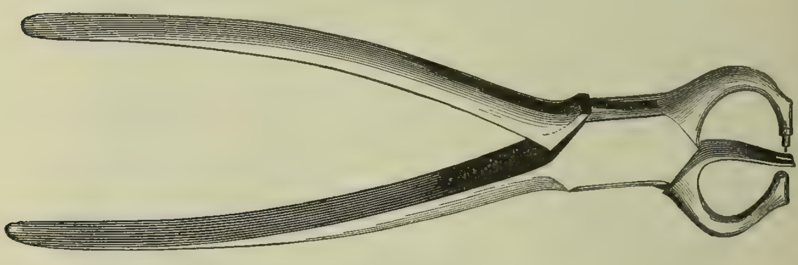
PREPARING FOR SOLDERING AND FOR MAKING THE BACKINGS.

Remove the cement thoroughly and carefully, especially from between the pins and from between and under the teeth, as if any is left it may run out when the case is heated for soldering, and, forming a coating upon the solder and the surfaces to be soldered, very seriously interfere with

that operation. Care is needed, however, because there is not only risk of displacing the teeth, but also a risk that if the instrument used is carelessly handled it may slip between the pins and fracture a tooth. The next step is to thoroughly scrape the plate where the solder is to flow, so as to present a bright clean surface, and to clean the pins. Cleaning the pins is very important: it is perhaps better, although not usual, to attend to it before grinding the teeth. The object of this cleaning or scraping is to remove a thin coating of porcelain usually found upon them, which if not removed would effectually prevent the solder from uniting. This is removed with a thin-bladed flat graver, so held and used that while it freshens the surface of the pin and removes any porcelain or other objectionable matter, it has no tendency to cut into it. The method of doing this is easily learned, but difficult to describe. The pins should be cleaned all around, special care being taken to remove the little cone of porcelain at the base; while doing this straighten those that need it and make them parallel to each other. It is well to remember that there is a risk of fracturing the teeth in performing this simple operation, especially if the teeth are ground so that the pins are close to the plate. After the sides of the pins are cleaned, with the same instrument or with a file brighten the ends or tops, and the case is ready for making the backings.

Making the Backings.—Before beginning to make the backings have close at hand upon the workbench the following tools: The plate shears; the punch for making rivet holes (Fig. 385); a strong pair of flat pliers

Fig. 385.



Rivet-punch.

(not too large), with beaks that will hold firmly; a half-round file; a point that can be used as a reamer; a tool for countersinking the holes—a triangular scraper, like Fig. 386, answers for this purpose nicely; a small hammer; the small bench anvil; the tweezers or soldering-tongs; and a graver for splitting the pins.

The thickness of plate to be used for backings will depend upon the length, position, and character of the teeth. In partial cases where the teeth stand alone, it makes no difference whether they are gum or plain: we have to consider only the strain likely to be put upon them. In large cases it is usual to place pieces of plate between the backings of gum teeth, uniting them at the base and extending them as high as is possible without their being seen when the case is in the mouth; this adds very materially to their strength and stiffness, and permits of a

lighter backing than plain teeth would require. Long teeth require a heavier backing than short teeth, and very narrow teeth heavier backings than wide ones. An average thickness for a gold backing is about No. 22; for one of silver, No. 20 (American standard wire gauge). The addition of a little platinum in the gold used for backings gives them greater strength and stiffness.

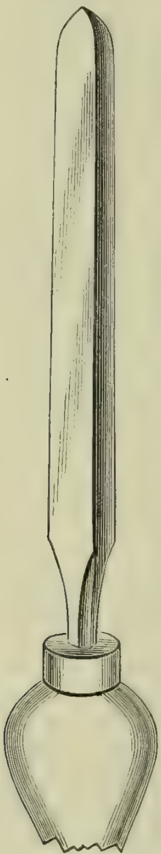
The backing should be made nearly as wide as the tooth. The length or height is sometimes a matter of taste; at other times it will depend upon the requirements of the case. If the anterior teeth are likely to be subjected to much strain in mastication, I prefer to make the backings go quite to the cutting edges, so that the opposing teeth will strike against them rather than against the teeth. If this is not the case, I prefer to let them end about halfway between the upper pin and the cutting edge; this leaves the cutting edge more translucent, and, I think, gives the teeth a more life-like appearance. The backings of the posterior teeth need not extend beyond the upper pin farther than is required for strength. Endeavor to make all the backings of a case as uniform as possible, with a general correspondence in height and shape; this gives the finished piece of work a much neater appearance. Fanciful shapes are always out of place: I prefer to make the corners rounded, the tops of those for the incisor teeth conforming somewhat to the shape of the cutting edge, the front corner slightly longer, and the backing neatly curved at the edges, as shown in Fig. 395; they look far neater thus made, and are more pleasant to the tongue. I object strongly to the style so much in vogue of making the outline square, the backings flat, with a straight, well-defined bevel at the sides and top. They have a stiff, inartistic appearance, require a great deal of care and skill to form them properly, and show very plainly if they are slighted in this particular—are more difficult to clean, present sharp corners to the tongue, and are altogether out of place.

When backings are to be made for a full upper or lower denture, considerable time may be saved by cutting several strips, about two or three inches long and of suitable width, and bevelling for their entire length both edges upon the side that is to be the face of the backing: the strip is more quickly bevelled than the separate backings would be. An upper denture requires the same width for the centrals and molars, and another width will serve for the laterals and bicuspids, and perhaps for the cuspids; so that if each strip is cut slightly wider at one end than at the other, so as to conform to slight difference in the width of the teeth, two strips will make all the backings. A lower denture usually requires three strips—one for the six anterior teeth, one for the bicuspids, and another for the molars. There is not only a saving of time in filing the sides, but the long strip held by the fingers can be handled more easily and more quickly than a short one held in the pliers. It is a good plan to make a line with a lead-pencil all round the backs of the teeth to indicate the height of the intended backings.

Having prepared the strips, place one before the tooth to be fitted, and, holding it in the position the backing will occupy, proceed to make it fit accurately to the plate by cutting with the shears or by filing.

When this is done hold it in position, and, pressing it against the lower pin, slightly move it from side to side or up and down, so that the pin will mark where the rivet hole is to be made; then punch the hole at the mark; place it again in position, holding it so that the pin enters the hole just made, and in the same way mark the position of the second pin, and punch a hole for that also. Place it again in position with the pins passing through their respective holes, and see that they enter them easily and without strain. If the holes are too far apart or too close, so that force is required to press the backing in place, there is danger of the tooth being broken during soldering. To remedy the first defect slightly enlarge the hole by punching a little from the side: the second defect is corrected by laying the strip upon the anvil and striking a few light blows with the blade of the hammer between the holes; this will spread them farther apart. Countersink the holes, slightly on the side next the tooth, but quite freely on the other side, and remove the burr raised by the countersink, using for this purpose the triangular scraper shown in Fig. 386. Then lay the strip flat on the bench, with the side that goes next the tooth uppermost, and strike a sharp blow with the blade of the hammer about the centre of its width, and near that end of the strip that has been fitted to the plate. The object of this is to slightly curve it, so as to make the edges fit more closely to the back of the tooth. Then place it on the tooth and see that it fits solidly and closely at the edges, and mark where it is to be cut off, making the front side a little the higher, so that it will be parallel with the cutting edge of the tooth. Lay it aside, and proceed in the same way until the backings for the teeth of the denture in hand have been cut off and laid in regular order. We are now ready to file them to shape. Take the centrals first, holding them firmly in the pliers; file the backings to the required shape. The side nearest the median line of all should be slightly the higher, and they should be filed so as to appear to lean slightly in that direction. To secure uniformity I recommend fitting them in pairs, each pair being made exactly the same width and as nearly alike as is practicable. This, if carefully done, adds very much to the appearance of the case. In filing the backings make them as nearly the desired shape as possible, leaving nothing that can be done with the file for the graver to do after they are soldered. I do not approve of making the pieces of plate placed between the backings of gum teeth to unite them at the base in one piece with the backings. To do so increases very much the labor of filing them to shape; wastes material, as the strips must be cut much wider; does not permit of so close a fit; and, unless great care is used, the backings cannot be made so neat and uniform. The advantages claimed for this method, that they are easier to

Fig. 386.



Triangular Scraper.

finish after soldering and that there is no risk of displacement, are trifling and practically of but little moment.

The backings of gum-finished molars should be made to conform to the shape of the tooth and the gum at its posterior edge, especially if the case is to be rimmed.

As the backings are filed to shape, I recommend that they be left on the teeth, but be not riveted until all are done. Quite frequently when they are all in place some little points in which they can be improved may be noticed that were not seen during the progress of the work, and which improvement cannot be effected after they are riveted. When they are entirely satisfactory, if for plain teeth proceed to rivet them. This is done by splitting the pins with the edge of a graver, neatly making two cuts at right angles to each other across the middle of each pin, and pressing apart the four quarters into which the head of the pin is divided, so as to completely fill the countersink. Care is required in this apparently simple operation to avoid making the cut oblique and thus cutting off a portion of the pin. The cut must be vertical—a difficult matter at times, as it is not always possible to use the graver in direct line with the pins on account of their position. I prefer, as in filing them to shape, to rivet the backings in pairs, and to begin with the centrals. They are handled at this stage with the tweezers or solder-tongs.

Before riveting press the backing with the points of the tweezers, and see that it rests against the tooth solidly, and that pressure at any point does not cause it to rock. This is important: if it rocks, it is impossible to rivet it so as to draw it close to the tooth. Next see that the edges fit the tooth all around, and that there is no space between the backing and the tooth at any point. If right in these respects, proceed to rivet, being careful not only to split the pins properly, but also careful not to displace the backing—a mishap that may readily occur. When both centrals are riveted examine them closely to see that they have been placed upon the teeth evenly, and that there is not more space between the edge of the tooth and the edge of the backing on one side than on the other. See that they have not been raised from the plate during riveting, and that they lean slightly toward each other. These defects, if they exist, are easily corrected by pressing the backing in the desired direction with the graver, and afterward with the same tool spreading the pins so as to hold it in place. After the centrals are satisfactory proceed with the laterals, then the cuspids, etc., in the same way. While riveting the backings any space between the teeth and the plate should be filled with scraps of the same metal of which the denture is made. If there is much space, add a little borax, ground or mixed to the consistency of cream, being careful not to let it come in contact with the teeth, and a few small pieces of solder, preferably of a more fusible kind than is intended to be used in soldering the case. Gold- or silver-foil has been recommended for this purpose, but I have not found it satisfactory; it cannot be packed solidly enough to make as clean a filling as the method suggested. After all the backings are in place, fit triangular pieces of plate between them wherever it can be done, so as not to show when the case is in the mouth, allowing them to lay flat on the plate or nearly so. These add very much to the strength and fin-

ish of the denture. In making them they are simply cut from a strip of plate with the shears. The point passes between the teeth a short distance, and should entirely fill the space between them, the base of the triangle being even with the backings of either side. The point may require bevelling from the upper side with the file, or many be bent down with the pliers to make it lay close to the plate; beyond this they rarely require any fitting, and are quickly made and placed in position. After they are adjusted, mix a little plaster quite thin, and with the point of a knife or a camel's-hair pencil pack it between and over the tops of the teeth, so as to cover the exposed porcelain at all points, first wetting the investment where plaster is to be added to it, so that they will unite. While doing this be careful not to add so much as to interfere with the free use of the blowpipe flame in soldering, and not to allow it to encroach upon any part where the solder is to flow; use special care not to let any get into the pinholes; if it does, it is almost impossible to remove it: its presence will effectually prevent the solder from flowing in, and reinvestment and resoldering will probably be necessary. The object of adding this plaster is twofold: first, to prevent the borax used as a flux in soldering from coming in contact with the porcelain, as when heated it may cement the material of the investment or the metal of the case to the teeth, and in either case is liable to roughen or to fracture them; second, to protect the teeth from direct contact with the blowpipe flame. The case is now ready to receive the solder.

With gum teeth the procedure is precisely the same, except that fitting the connecting pieces between the backings is a little more complicated. After the backings are all completed and in place, but before riveting, mark with a lead-pencil or a sharp point on each backing the height desired for the connecting pieces. It is desirable that they should extend above the pin nearest the plate; if below this, they add but little to the strength of the backing; to look well they should also be uniform in height. Cut a strip of platinum-foil or platinum-plate rolled very thin, wide enough to considerably overlap the widest space between any of the backings. From this cut pieces as long as the height of the connecting piece of the centrals and between the centrals and laterals; remove the central and lateral backings, and place these three pieces in position; replace and rivet the central backings, and proceed in this way until all the spaces between the backings have been thus treated and the backings riveted. The backings overlapping the platinum strips hold them in place, while the platinum, being so extremely thin, does not materially keep the backing from the tooth. Observe the precautions in regard to the position of the backings and splitting the pins previously referred to. Then with a burnisher burnish the platinum close to the teeth and into any interspace that may exist between them. This platinum is not intended to form the connecting piece: its object is, first, to protect the tooth from the borax; second, to prevent a "pocket" being left between the teeth back of the connecting piece; third, to ensure metallic contact between the backings, so that there will be no difficulty in getting the solder to flow in; and fourthly, on this account it very materially prevents the connecting pieces from being displaced during soldering. Platinum is used for this purpose with either gold or silver plates: its cost is a mere

trifle; even in silver cases it is repaid by the solder it saves. The connecting pieces are now fitted. If the spaces are narrow, they may be filled with scraps taken from the drawer or narrow strips cut with the shears; if wide, they may require a strip bevelled on each side to fit the bevel of the backings. They require far less careful fitting when the platinum is used. They are held in place by a little borax, such as is used in soldering, applied with a camel's-hair brush. It is surprising how very much the platinum simplifies this part of the operation, while its assistance during soldering is equally great. When the connecting pieces are all fitted and in place, add plaster as before directed; but more care is required, as the plaster must be made to slightly impinge upon the connecting pieces to assist in holding them in place while soldering, but must not be allowed to run into any place where the solder is intended to flow. When this is all done the case is ready for soldering.

The methods just described are for the moulded teeth selected at the dental dépôts. Carved blocks require different treatment. In a full denture the six anterior teeth are usually made in one block: the backing of this is very difficult to fit in one piece. The position of the pins and the peculiar shape and curve of the back of the block must be considered when deciding into how many separate pieces it should be divided. The bicuspids and molars are usually made in one block also, making three blocks for a full denture. The posterior block is usually much easier to fit, and may frequently be made in one piece to advantage. In fitting the separate pieces of which the backings are composed they are made to overlap, the edges being bevelled to lay over each other, so that when soldered they form a continuous band from end to end. In making them fit cut the separate pieces a trifle longer than they are intended to be, and while they are all in place make a line with a sharp point all round to indicate the height; file them to this line carefully, and get them all quite even before bevelling the upper edge. The pins of hand-carved blocks require more care in cleaning and straightening, and often require filing down before attempting to rivet. Be careful that the backings go on easily and without strain; if the pinholes are a trifle large, the pins can usually be spread after splitting to fill them up. Carved blocks are not as dense and strong, and do not bear soldering so well, as moulded teeth; therefore they require extra care in backing and soldering to prevent accident.

Some contend that there is more risk of fracture in soldering carved blocks when the backings are united, and recommend that each pair of pins should have a separate backing, as for moulded single teeth, or that the backing of each block should be separate and not united to the backing of the adjoining block. I have not found this to be of the slightest moment, and as the continuous band is stronger and more cleanly, and far more artistic, I approve of and recommend it.

Backings for partial cases with carved blocks or where moulded single teeth are used require no special directions: the changes necessary are self-suggestive, except in those cases where the bite is close and cuspid teeth are used in place of bicuspids, or where from other cause it is necessary to build up metallic cusps or steps upon which the antagonizing

teeth may bite. Generally this has to be done by the eye, unless the case is first soldered and the cusps are afterward added at a second soldering—a procedure rarely called for. There is no difficulty in judging with sufficient accuracy their position and height. In these cases, after the backings are riveted and the case otherwise prepared for soldering, if the cusp is not very high cut thick pieces of plate, pile them one upon the other until they are high enough, remove, and lay them aside. After the teeth to which they are to be added have been soldered place them in position and solder them. If they are placed in position before the teeth are soldered, as they usually cover one or more of the pins, it would be difficult to make the solder flow back of them to securely solder the pins and the base of the backing. When the cusps are high or large a box is sometimes made, fitted, and laid aside, to be added and soldered after the teeth are soldered. These cases may tax the workman's ingenuity, but are not difficult and call for no detailed directions.

In all partial cases the portions of plate passing through interspaces must be strengthened by laying an extra piece over them: this should extend far enough over the plate to strengthen all manifestly weak points. An extra piece should be used to strengthen the attachment of clasps and around the spaces cut out to permit the plate to fit around remaining natural teeth; the latter pieces should not be placed at the extreme edge of the plate, but slightly inside. If placed upon the extreme edge the solder may cause the edge to curl up, or at some time the edge may require bending, which cannot be done if the solder is flowed over it. These extra pieces are usually picked from the scraps in the drawer, and are readily fitted with the pliers. Always make sure that these extra pieces are fully up to the backing of the teeth they are intended to strengthen, and when they are used to strengthen where the plate has been cut away be sure that they extend all the way round and leave no point not strengthened. If a little space is left between two extra pieces in such a case, the plate will surely crack at that spot; it is really weaker than it would be without them.

Some operators prefer to make the backings and solder them to the teeth, and to finish and polish them before soldering the teeth to the plate. The advantages claimed for this method are that all the work of finishing can be done with a file and felt wheel, and that it is easier and time-saving to finish and polish the backings while the teeth can be handled separately.

Against this may be urged the risk of a second soldering, and the risk of changing the position of the teeth by taking them off the plate and replacing them, etc. In special cases it is sometimes best, but I do not consider it so as a rule.

If this method is preferred, instead of investing the case place it upon the plaster cast, make cone-shaped holes or V-shaped grooves at intervals around the front of the cast, and, after oiling it to prevent the added plaster from uniting, build on plaster, extending from the bottom of the cast to a little above the cutting edges of the teeth and about half an inch thick. This is intended to take the place of the investment in holding the teeth to the plate while the backings are fitted and riveted to the teeth,

and to serve as a guide in replacing them after they have been soldered and finished. Proceed precisely as though the case was invested in the usual manner until the backings are riveted to the teeth. After this is done remove the guide or matrix: to do this it is generally necessary to break it into several pieces. Remove the teeth from the guide, and, placing upon a piece of glass sufficient plaster and sand, mixed precisely as directed for investing, to hold from three to five teeth, smooth the surface, and lay the teeth upon it, about half an inch apart, with the backings uppermost; press the teeth into it, and with a knife-point make it slightly overlap the backings all around, being equally careful to keep it from the pins and to thoroughly cover the porcelain. The investment should be about half an inch thick. When the investment is hard, apply borax to the pins, add sufficient solder—preferably a harder-flowing solder than is intended to be used in soldering them to the plate—heat them in the usual way to nearly the fusing-point of the solder, and flow the solder with the blowpipe, making sure that the solder does not flow over, but that it flows into each pinhole thoroughly. If simply flowed over the pin, as hard-flowing solder is apt to do, it will probably be all removed in finishing and polishing, leaving the pin unsoldered. When the teeth and investment are quite cold (never hurry the cooling of teeth; let them take their own time), remove them, pickle to remove the borax, finish and polish the backings, place the teeth in the guide, adjust it in place, and again fasten the teeth to the plate with cement. If they are gum teeth, do not forget to place paper between them before investing. When all is ready invest for the final soldering as previously directed. After removing the cement fit the connecting pieces, if they are required (in these cases they must be fitted far more carefully and accurately), and proceed to prepare for soldering precisely as though the backings were only riveted in place.

Soldering.

A solder, if an alloy of the same metals as the plate upon which it is intended to be used, is necessarily of a lower carat. The 18-carat gold plate usually used is an alloy of gold, silver, and copper; an alloy of these same metals 15 carat fine would be for it a suitable solder. Varying the proportions of the silver and copper with which the gold is alloyed varies somewhat its fusing-point, but not to so great a degree as does varying the proportions of the gold and the alloy. Solders of this class flow freely, but they require all the joints to be made close, as they will not bridge over any spaces between the pieces to be united. They are also somewhat difficult to cut with the graver in finishing, on account of their hardness.

For dental purposes a gold solder is desired as fine or nearly as fine as the plate. To obtain this the gold must be alloyed with a metal having a lower fusing-point than any which enters into the alloy of the plate.

Zinc is the only metal suitable for this purpose, as it enables us to produce a solder quite as fine as the plate upon which it is used. In addition to its fineness the zinc alloy has other advantages: when fused

it is less fluid than the alloy of silver and copper and will bridge over slight spaces; in hardness it is more like the plate, and it is much easier cut with the graver in finishing; in soldering the zinc is slightly volatilized, making the solder after it has been fused rather less fusible than it was before, and thus reducing the danger of roughening it in subsequent solderings. On the other hand, it requires more careful treatment under the blowpipe, and unless promptly fused is prone to oxidize and become unmanageable.

To make the zinc-gold solder take 1 pennyweight of the same gold upon which it is to be used, and add $1\frac{1}{2}$ grains of zinc. If this is done in a crucible in the furnace, first fuse the gold (which should either be clean scraps or be cut from the plate; never use filings for this purpose), using but little borax; when thoroughly fused, take the crucible in the tongs, drop the zinc into it, give the crucible a rather vigorous yet skilful shake to assist in mixing its contents, but without causing any to be thrown out, and immediately pour into the previously prepared ingot-mould. This must be done very quickly, or the solder will require too high a heat for fusion on account of a large proportion of the zinc being volatilized or oxidized, and thus be lost as alloy.

This formula applies to all kinds and grades of gold plate, and produces a solder that flows freely upon, and is nearly as fine as, the alloy from which it is made. If only a small quantity is needed—say up to 5 or 6 pennyweights—it can be conveniently made under the blowpipe in the following manner: Place the gold upon a piece of broken crucible or a flat black-lead crucible; either is better than laying it directly upon the charcoal or other support. Apply heat until the gold fuses, but do not get it too hot; add the zinc, which usually chills the gold, so that the union is incomplete; if we now apply the blowpipe flame to again fuse the gold, a greater or less portion of zinc will be burned out, leaving a very uncertain alloy. We therefore allow it to cool, forge and roll it quite thin, cut it in small pieces, and remelt it. In this way we ensure thorough mixing without risk of burning out the zinc. The resulting alloy is usually quite brittle when rolled, but makes a strong and satisfactory solder. I prefer, however, to make the solder from pure gold, reducing it to the required carat with silver solder and zinc, in the following proportions:

Pure gold	18 grains.
Silver solder	5 "
Zinc	$1\frac{1}{2}$ "

There is always a slight loss of zinc, so that we may consider that this gives an 18-carat solder. Any carat may be made by changing the proportions of gold and silver, the quantity of zinc remaining constant.

Before using solder on a case it is best to test it in the following manner: Take a scrap of silver plate; scrape the surface and cover it with borax, and place a piece of the gold solder upon it. If it is safe to use upon 18-carat gold for soldering teeth to the plate, it should flow freely over the silver without the silver being overheated in the slightest degree. A solder fusing at a much higher temperature can be used upon 18-carat gold, but it is neither necessary nor wise to attempt its

use for soldering teeth. The zinc should be as pure as it can be obtained; especially should it be free from even a trace of tin or lead. I have found sheet zinc satisfactory as to purity and in a convenient form for use.

Silver solder is made by alloying fine silver with one-third its weight of brass. The zinc of brass reduces the point of fusion to a convenient degree. Should a freer-flowing solder be preferred, the addition of a little more zinc—from $\frac{1}{2}$ to 1 grain to a pennyweight—reduces the fusing-point far more than it reduces the fineness or the quality of the alloy. I prefer, in laboratory practice, to have one standard solder for each metal, and have selected that standard with special reference to its use for soldering teeth. If a harder-flowing solder is required, it is readily made from this by adding to it from one-fourth to half its weight (or more) of plate. It is so seldom that this is needed that I prefer to make it as it is required, under the blowpipe, in the following manner: Take the desired amount of plate in the form of scraps; fuse them together with the solder; allow it to cool, and then roll it very thin and remelt; forge and roll to the desired thickness. As little as a few grains can be quickly made, just enough for the operation in hand. In this way we can make the solder to suit the work and avoid the danger of mistaking one grade for the other. It takes but little time—far less than would be required to repair the injury liable to occur from attempting to flow a piece of hard-flowing solder placed upon a case by mistake.

Many of the formulas for silver solder given in works upon this subject are of far too low a grade for use in the mouth. For use, the solder is rolled to about No. 26, annealed, and treated with acid, so as to make the surfaces quite clean; it is then cut into pieces from one-sixteenth of an inch square to about one-fourth inch long by one-eighth wide, depending upon the use to be made of it. The zinc-alloy gold solder is often quite brittle under the rolls if made from plate; if made from pure gold, as directed, there is seldom any difficulty in this respect.

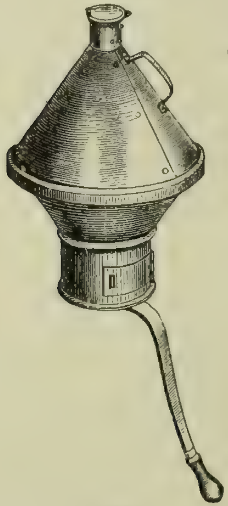
Soldering.—After the backings, extra pieces, etc. are in place the case is ready to receive the solder; before applying it, however, carefully examine the case and note any points that may require special attention during this operation. In partial cases there may be clasps whose usefulness would be impaired if their free ends were united to the plate or to a backing which they nearly or actually touch. To prevent union in these and other like cases place a little plaster, mixed quite thin, so that it will run well into the space between the clasp and plate or backing. Whiting may be used in the same way for the same purpose, and is preferred by some. All places where it is desired that the solder should not flow should be thus protected. Again, there may be places difficult to reach with the blowpipe flame; as, for instance, in cases where we have to solder a narrow tooth placed between two wide clasps. In a case like this it is difficult to solder the tooth without at the same time soldering the clasps; therefore, in addition to protecting the clasps with plaster, use very little solder at a time, so as to have it well under control. Remember that solder cannot be depended upon to bridge over wide spaces: for this reason scraps of metal should be fitted in all spaces where they can be placed.

To mix the borax, add water and rub down a crystal, grinding it with a muller upon the borax plate until it is about the consistency of cream, quite smooth, and free from small gritty particles. Apply this with a camel's-hair pencil or a stick of wood with a wedge-shaped point to all places where it is desired that the solder shall flow, using it rather more freely upon silver than upon gold.

Pay special attention to the pins; see that it runs well around them. Apply the solder, first coating it with borax by placing it upon the borax plate; it is placed upon the case with the solder-tongs. I prefer to lay the solder mainly along the base of the backings, and depend upon the judicious use of the blowpipe flame to make it run into the pinholes, etc. If the backings are long, a small piece may be placed over the pinhole and near the top of each connecting piece. Place narrow strips at intervals along the extra pieces, etc. I prefer not to apply too much solder a first, and depend upon adding more as it is needed during the operation. If too much is put on at first it is difficult to manage.

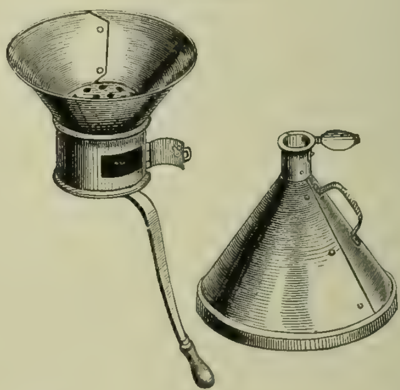
Heat the case slowly and evenly in a furnace or over a gas stove. The best method of heating a case for soldering is in a muffle in a small furnace, such as is used for baking teeth. If the heat is applied too quickly, the borax crepitates, the water of crystallization it contains being driven off so rapidly that the borax swells and displaces the solder. If heated very quickly or unevenly there is great risk of breaking the teeth. The heat should be slowly raised until the plate is of a dull-red color or to nearly the fusing-point of the solder. If the plate is for a very deep mouth, or if from any cause the investment under any part of the case is very thin, care is required in applying the heat, or those parts of the plate necessarily more ex-

Fig. 387.



Closed.

Fig. 388.



Open.

Charcoal Soldering Furnace.

posed to the heat and less protected by the investment may become overheated, in some cases even fused, before the plate immediately under the backings is sufficiently heated. For soldering large or difficult cases,

especially where hand-carved blocks are used, I much prefer the portable charcoal furnace shown in Figs. 387 and 388. In this arrangement the case can be heated slowly and thoroughly: by placing the charcoal well around it the heat reaches the teeth better than by any other means, the case is readily soldered without removing it from the furnace, and after soldering it can be closed up so as to cool slowly. The even distribution of heat is very important, not only to avoid breaking the teeth, but also to cause the solder to flow easily and smoothly. When sufficiently heated place the case upon a convenient support for handling it under the blowpipe (as just stated, the soldering furnace may be used as a support), and proceed to flow or run the solder.

It is very difficult to give directions for soldering a case. It is one of the things that can be learned, but cannot so well be taught. Watching a skilled workman perform the operation, a little real practice, and a few failures will give the learner more assistance than many pages of instruction. There are a few points of general application, however, that it is well to remember: Always endeavor to heat the parts to be soldered more than the solder. If the heat is applied to the solder direct, so that it reaches its fusing-point before the parts upon which it is placed are equally hot, it rolls up into a ball, and in this condition often gives a great deal of trouble. Solder always has a tendency to flow toward the hottest point; this tendency enables us to direct its course under the blowpipe. Watch the solder closely, and when just on the point of fusing, if it shows a tendency to flow in a wrong direction, immediately direct the blowpipe flame so as to heat the point toward which it is desired the solder shall flow. Learn to notice the changes which take place in the solder just before it fuses, so as not only to recognize but also to command them. As the heat increases the solder first lays closer to the work; the borax with which it is coated and surrounded fuses and allows it to come into contact with the parts underneath: next, to use a technical term, it "sweats"—that is, it is fused upon the surface and softened throughout its mass, and unites with the metal it touches superficially. Advantage is quite frequently taken of this condition to make the solder itself hold the pieces we desire to unite in place, and to counteract the tendency it has to draw them out of place when fusion occurs. For example: when we are soldering an extra piece to a plate or long connecting pieces where there is little or nothing to hold them in place, the heat is directed around a piece of solder so placed that it will hold in place the pieces we wish to unite until it is fixed in its position by sweating. Another piece of solder a little distance from it is now fused: its tendency to displace the piece is too slight to effect the attachment of the first piece, which may now be made to flow freely without any risk of the parts soldered changing their position. Or, again, in the case of a connecting piece a strip of solder is placed over it long enough to rest upon the backing on either side; the blowpipe flame is carefully applied so as to "sweat" the solder to the backings and the piece uniting them; the heat is now increased until the solder flows without any risk of displacement, while if this care had not been used it is likely that the solder in flowing would have drawn the piece out of place toward the backing which happened to be the hottest. This

idea is constantly used in soldering a case. Indeed, the ability to use it instinctively, without stopping to think, is really what makes the workman an expert. Watch the case closely, and follow with the eye every piece of solder until the last has been satisfactorily and smoothly fused. Especially watch the pins, and by applying the heat to the backing make the solder flow up behind it and through the pinhole, adding a small piece of solder, if necessary, to fill it so as to make a neat finish, but not until the solder has appeared around the pin: if the solder is applied first, it may run over the pin without flowing well into the hole, and, even if not cut off in finishing, will thus leave the pin really unsoldered, and will always remain a weak point. It is desirable that the solder should take hold of the pins close to the tooth; if it does not, there is a probability that the platinum will stretch, allowing the tooth to leave the backing and permitting a slight motion of the tooth, which soon breaks one or both pins. Watch the solder closely as it flows, and see that it flows into every crack and crevice. While fused it is readily seen, but a moment after it has chilled it is frequently impossible to say whether a certain point is really soldered or whether the borax has flowed over or into it. This is specially liable to occur to the pinholes and at the sides of the connecting pieces. A rod of steel about six inches long and three-sixteenths of an inch in diameter, set in a wooden handle and with a moderately sharp point, is very useful for directing the solder, or for holding small pieces in place, or for replacing them after they have been displaced. This soldering-point is almost indispensable. The point is slowly melted by frequent contact with the fused solder, and no doubt a small portion of the steel unites with the solder, but the amount is so very minute that we do not consider the objection made to it on this account of any practical moment. Simply flowing the solder in the right place and uniting all the pieces that form the case is not all that is required; it should be thoroughly fused and made to flow smoothly, and sufficient should be added to round the sharp angle at the base of the backings and at other points so as to make a neat finish. To accomplish this requires the heat to be raised above the fusing-point. Smooth soldering is more than labor-saving: no after-finishing can make a good piece of work of a badly soldered case; much of the artistic finish depends upon making the solder flow thoroughly, smoothly, and evenly. If sufficient heat is not applied the solder is in a measure simply sweated into position; after the case is finished the solder remains porous, which detracts very much from its appearance and also from its strength. This condition may also be brought about by bad solder, or by a hard-flowing solder, or by keeping the solder too long under insufficient heat whereby it becomes burned or oxidized, or by using too little borax or borax that is not clean or contains sand or grit.

Some workmen endeavor to so thoroughly heat the case before using the blowpipe that the soldering is finished in a few seconds by simply passing the flame around it. When this can be done there is certainly far less risk to the teeth, but, as I have found that although the solder has been flowed smoothly and well there have usually been some points missed, perhaps several pins, thus necessitating a second soldering, I do not consider the practice commendable, and prefer to take a little

more time, commencing at one side, passing around the case, and making sure that every point is thoroughly done.

Some cases are specially difficult: for instance, a lower case where the ridge is very narrow and where the teeth lean inward. Occasionally, in such cases it is necessary to first solder the backings, and then to turn the case over to solder the backings to the plate. In these cases it is very important to watch closely all parts of the work: if the attention is too closely fixed upon the part we are soldering, it is possible for the blowpipe flame to be deflected, and without being noticed overheat a distant part of the case.

Soldering the teeth is the most trying and difficult operation in constructing an artificial denture. It occupies but a short time, but completes or may make useless all that has previously been done. It requires skill, quick and good judgment, and to ensure complete success a nicety of observation that but few really attain.

After the case is soldered lay it aside to cool slowly; on no account hasten it. When cold break off the investment; if any portions are united to the teeth by the fused borax, do not disturb them; the acid, by its action upon the fused borax, will remove them without risk, while the attempt to break them off may mar or roughen the porcelain beneath them. If the gums have been ground very thin, place the case in warm water to soften the investment before attempting to remove it.

After removal of the investment place the case in a pickle composed of equal parts of sulphuric acid and water, to dissolve the fused borax, etc. and to cleanse the case. If it is needed quickly, the case may be boiled in this bath; if time is no object, this is unnecessary. A strong solution of common alum may be used in place of the acid: it has the advantage of not being so corrosive and destructive to the clothing as the acid, but the case must be boiled in it to effect the object. After removing it from the pickle thoroughly wash in water containing a little soda to remove the acid. Examine carefully to see that the teeth have received no injury and that the soldering has been thorough. If any defective soldering is noticed, the case may be reinvested and the defect remedied at once, although it is better first to finish the case and prepare it for polishing, for fear that some other defects may develop during that operation.

Finishing and Polishing.

There now remain two distinct operations, finishing and polishing, through which the case must pass before it is ready for the mouth.

Finishing is preparatory to polishing, and consists not only in shaping and smoothing the surface, but also in making it as uniform in density as possible, so that all parts of it will receive an equal polish.

Polishing may be conveniently divided into two distinct operations: First, surfacing, or removing by abrasion the scratches made by the cutting tools in finishing, and leaving a dead-smooth surface. Second, after this is done, by the use of very hard and very fine abrading materials this surface is still more smoothly polished; the scratches made while surfacing are reduced in size and the surface becomes bright and glossy.

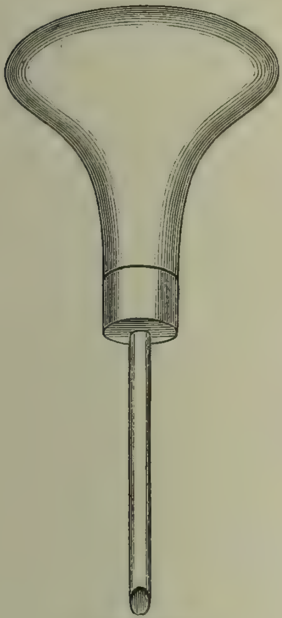
It is really burnished, for the finest polishing powders used for this purpose, however smooth they may feel to the touch, consist of extremely hard yet extremely minute particles. Their excellence as polishing powders is due not only to their hardness and fineness, but also in as great a degree to their uniformity in these respects, the scratches they make being so minute and uniform as to be unnoticeable.

The finishing of a case is frequently made unnecessarily difficult by carelessness in its construction. Deep indentations are made in the plate by the careless use of the hammer in fitting it to the dies or by using a hammer with a rough face instead of one with a face as smooth and as well polished as a burnisher. The careless use of the pliers when bending the plate to shape or the employment of a rough die will also not only make additional labor, but frequently will mar the plate so badly as to render it impossible to remove the defect. Careless soldering also is a time- and labor-waster : pieces of solder may become displaced, and remain unnoticed until they are fixed in position so firmly that they cannot be removed, they being then left to be filed or cut away with the graver in finishing. Rough soldering, carelessness in making and shaping the backings, in making and fitting the connecting pieces, or in fitting extra pieces, etc., or in adding insufficient solder to fill up sharp angles, not only make a great deal of extra work in finishing, but are liable to make a neat, artistic finish impossible. Neatness and care at every stage of the work, especially in preparing the case for soldering and in soldering, will very much facilitate its preparation for polishing, but will not, as some works on this subject suggest, enable us to omit it altogether, unless the operator's ideas of an artistic denture are but moderately developed, and he values *polish* more than *finish*.

I have seen cases soldered as smoothly and as neatly as it can possibly be done, but have never seen a case, even when the backings have been finished and polished before they were soldered to the plate, that did not require considerable work with the file, scraper, and graver to prepare it for polishing. No matter how smoothly the solder has flowed, there is always a line requiring removal where it joins the plate, and there are always a number of points that must be properly shaped and smoothed before the work of polishing is commenced if a really well-finished piece of work is desired. The entire surface of the plate, although to the eye it may appear perfectly smooth, requires scraping with a very sharp, smooth-edged triangular scraper, like Fig. 386, to remove the "skin," as it is termed ; for, no matter how carefully the plate has been made, or how free from marks and scratches it seems, the stretching and bending, the oxidation from annealing and soldering, produce a dense and broken surface that will not take a uniform polish ; it must be removed and the plate "surfaced," as mechanics term it, or it will present a mottled and scaly appearance which no mere polishing will ever remove. It is not necessary that this scraping should remove any perceptible amount from the thickness of the plate. The scraper is handled lightly, like a burnisher ; the scratches it leaves, if the work is skilfully done, are fine, uniform, and readily polished out. The felt wheel or sandpaper or their substitutes cannot take the place of the scraper for this purpose.

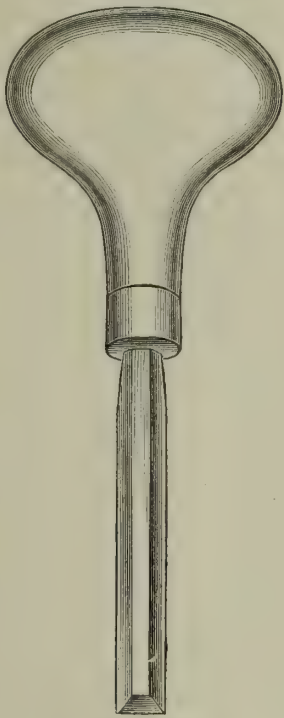
The tools used in finishing are fine-cut, half-round files, preferably about five or six inches long—one the same size or smaller, but dead smooth; round and flat gravers (Figs. 389 and 390); and a scraper

Fig. 389.



Round Graver.

Fig. 390.



Flat Graver.

(Fig. 386). The scraper and the gravers should be sharp, and as the work proceeds be kept sharp by the frequent use of a whetstone.

There is a little knack in handling the work which many operators fail to acquire, and yet it is very important, not only to the operator's comfort and safety in using the tools, but also to the well-being of the case. The work should be held firmly in the left hand by the fingers only, and not be grasped by or allowed to rest in the hand. It should be held and supported immediately under where the tool is being used, and to avoid bending the plate the other portions of the case should be entirely free, the fingers being so disposed as to protect any weak gums or other part specially liable to injury. It should be held solidly, but not be allowed to rest against, or even touch, the workbench: always let it rest against one of the fingers, and let the finger rest against the bench. When from its size or peculiar shape there seems danger of bending the plate, or where the gums are long or are ground so as to be weak, I have seen placing the case on the plaster cast or building plaster under the plate and around the weak gums recommended as a precaution against accident. Both methods are objectionable. The work cannot be so

readily done upon the cast, and the protection it affords is far less in practice than might be supposed. If the proper method of holding the case has been acquired, a little care to prevent the case falling from the hand is all that is needed to prevent danger from bending the weakest plate or breaking the frailest gums.

Some little skill is needed to handle the graver effectively. It requires a degree of force to thrust the tool steadily forward while cutting into the metal, and yet at the same time its movements must be so thoroughly under command that it will not slip if the resistance to it is suddenly overcome. To effect this the thumb of the right hand, which holds the tool, should always rest against the work or against one of the fingers of the left hand, holding or supporting it; this steadies the hand. The tool is so held to the work that while it cuts off a clean shaving it has no tendency to dig into the metal; in this position it does its work with the least expenditure of force. It is held in the hand firmly, the head of its peculiarly shaped handle resting solidly in the palm of the hand, while the fingers rest upon and grasp the blade. The thrust of the tool is made either by a peculiar movement of the hand rotated at the wrist, the end of the thumb that rests upon the work forming a pivot, or by a peculiar movement of the thumb of the right hand whereby the palm of the hand moves forward, carrying the tool with it (the wrist remaining stationary), and the tool sliding over and being in a measure guided by the ball of the thumb. In all operations at the workbench, with but few exceptions, the elbows should rest firmly against the sides, so as to brace and steady the movements of the hands. There is nothing so ungraceful or so destructive to that combined firmness, suppleness, and steadiness so essential to good work as the practice of "sprawling" over it. If the workbench is of convenient height and the hands and arms are held as directed, the body is upright and well supported; it is in a position that can be maintained without undue fatigue, the breathing is free, and the digestive apparatus unrestrained. If the elbows are widely separated from the body—a position too frequently seen—there is a tendency to lean forward and to naturally assume a position in which some of the muscles of the trunk are idle while others are unduly strained; hence it is fatiguing. The stomach is pressed upon and the muscles of respiration are seriously impeded in their movements. It is not only an unhealthy and uncomfortable position, but it is also destructive of that steadiness this work specially requires.

With all care the tool will occasionally slip; this may be expected: therefore so dispose the fingers and the hand holding the work that they may escape injury.

In using the file for finishing the backings, etc. the handle may be dispensed with. The file is grasped near the point by closing the fingers upon it, and with the thumb steadying the hand, as in using the graver, it is used with short, quick strokes. As the point only is used, it is best to use a new file for this purpose; when the point becomes dull, half an inch may be broken off, making it as sharp as at first without injuring it for general use after it ceases to be useful for finishing.

The triangular-shaped scraper (Fig. 386), conveniently made from a

worn-out three-sided file, is used to surface the plate and to cut down any rough or uneven places, and is held and used somewhat like the file.

In commencing to finish a full denture, either upper or lower, first see that no part of the backings or connecting pieces will be seen when the case is in the mouth. Quite frequently at some points the backings may be too wide or the connecting pieces too high; first correct this, and then proceed to finish the backings. Begin with the six anterior teeth, first removing with the file or graver the roughness caused by the pins projecting through the backings; then trim the backings into shape with the file or graver, as may be most convenient. I prefer to use the graver wherever it can be used to advantage; in skilful hands it is far more effective than the file, and does not flatten the work as the file is apt to do. In using the graver in finishing the backings care must be exercised not to get it between the teeth in such a way as to pry them off nor yet to allow its edge to get between the backing and the tooth. Both accidents are liable to occur, and both are destructive. Endeavor to preserve and improve the shape given to the backing when making it, rounding it from side to side rather than bevelling the edges, and at the top rounded in contour as well as in outline. Remove as little as possible from the face or thickness of the backing, so as to preserve its strength. In using the graver with a down stroke upon the backing, two things are to be avoided: first, the tendency to cut away too much from the base of the backing—as a rule, the tool should not reach this point: in a neatly-soldered case this point requires no further finish than a slight scraping with a round graver to remove any unevenness and give it a good surface for polishing; secondly, avoid a like tendency to cut away the backings of gum teeth about the top of the connecting pieces, just where the stroke ends in these cases when cutting off the solder over the pins. While finishing the backings see that the edges fit closely to the teeth; if they do not, make them do so with the burnisher—if need be making the extreme edge very thin, so that it can be bent up closely. Endeavor to remove as little from the backings as possible, and to remove it only from those portions where it is necessary to do so to make them the proper shape. In plain teeth carefully round the space between the backings, and do the same to the connecting pieces of gum teeth, making the extreme upper edge thin, and with the thin blade of a burnisher burnish them well to the teeth, so as to close any pocket that may exist there and leave no place for the lodgment of food, etc. This interspace is usually finished with the round graver. While finishing the backings remember the instruction given for making them, and preserve the uniformity there recommended. After the backings are completed round the base, removing as far as possible all sharp angles.

Endeavor to make the backings of gum teeth, as high as the tops of the connecting pieces, as nearly as possible like a continuous band all around the case. The scraper will be found quite useful in producing an even surface, and can be used to advantage in many places. After the backings and adjacent parts are finished proceed to scrape the plate to remove any scratches, indentations, or other defects, and to finish around the vacuum-cavity, etc.

The finishing of partial plates needs but few special directions; the difference in their form and shape will suggest any changes required. Where extra pieces have been added endeavor to so neatly remove the edges and to blend them with the plate that their presence will scarcely be noticed, and yet as carefully avoid impairing their strength. In all cases with plain teeth intended to rest upon the natural gum carefully and neatly remove the plate between them, so that it will not be seen when the denture is in the mouth, and also with the burnisher make the plate fit closely to the teeth on the palatal surface, filing it thin, if need be, to more readily effect this. Give the edges of the plate special attention, making them not only smooth, but rounding, using the dead-smooth file for this purpose.

Lathe burrs of various shapes are frequently recommended for finishing plate work: I consider them entirely inadmissible. If the case has been smoothly soldered, there is no necessity for tools like these: that they cut rapidly, and that they can be made to reach almost every part of the case, I admit, but they are too unmanageable for use on delicate work like this.

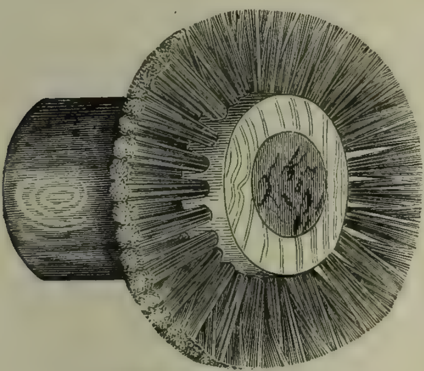
In finishing plate work not only keep the tools sharp, but see that the edges are smooth and even, and that they cut smoothly and do not leave deep scratches and ridges. The point of the file is often very sharp, and needs rounding on the grindstone to prevent it from making deep scratches. The point of the scraper may also mar the work unless carefully watched.

After the finishing is complete very fine sandpaper may be used to advantage upon some parts of the case, especially where a smooth, flat, even surface is desired, such as on the backings of block work, the lower portion of the backings of gum teeth, etc. It should be used very cautiously upon the backings to avoid making them flat, and should always be used in the hand or folded over a flat piece of wood. Never use it on a revolving tool in the lathe. If sandpaper has been used, always carefully wash the case with warm water and soap to remove all particles of sand before attempting to polish: if this is neglected the sand may cause quite deep scratches in subsequent operations.

The case is now ready for polishing. To remove the scratches left by the tools used in finishing, and to produce a fine smooth surface, I prefer Scotch or water-of-Ayr stone—a stone used by marble-workers, from whom it may be purchased. It comes in blocks from two to three inches square and from six to ten inches long. For use it is sawed into pencils about one-eighth of an inch square and as long as the block is wide. This can be done with a wood-saw if it is frequently sharpened, but it is a troublesome process: if it can be purchased ready cut it is far better to do so. There is considerable difference in its quality: for polishing purposes it should be moderately soft, of a fine texture, and free from hard particles, which appear in the block as black specks or spots. With an old file or by rubbing it upon a common clay crucible sharpen the pencil to a flat or round point as may be needed. This pencil is rubbed over the case lightly, the point being frequently moistened with a paste of pumice-stone and water. This is apparently a simple operation, but if the case has been neatly finished it is possible

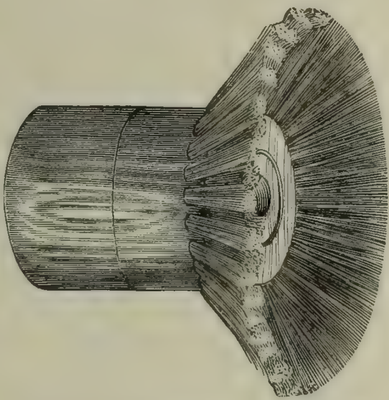
to injure its appearance by the injudicious use of Scotch stone. It should be used with reference to the shape and form the various parts of the case are intended to have, and care should be taken not to flatten rounded surfaces. It does not cut very rapidly, but by using it skilfully, giving special attention to those points which cannot be reached

Fig. 391.



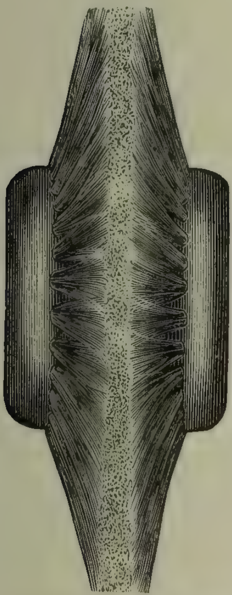
Small Brush Wheel for surfacing.

Fig. 392.



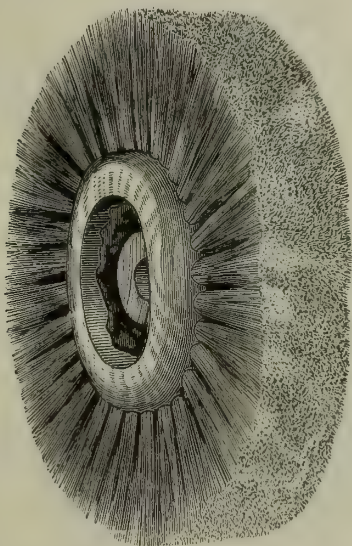
Brush Wheel, cup-shaped, for surfacing.

Fig. 393.



Stiff Brush Wheel for surfacing.

Fig. 394.



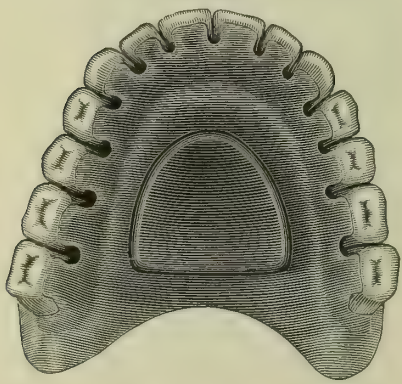
Soft Brush Wheel for polishing.

with the brush wheel, a smoothly-finished case can be surfaced in from two to three hours: silver is rather more rapidly done than gold. This operation is termed "stoning," and is essential to a well-finished piece of work. Felt wheels, corks, cones, etc. cannot take its place: they

may be used to expedite the finishing of cases where rapidity is preferred to excellence, but they all tend to produce flat surfaces and destroy the roundness and contour that give beauty and finish to a dental plate. The case is occasionally washed to examine the progress of the work. Any deep scratches or other defects that may have escaped notice during finishing should be removed with the scraper or graver as soon as seen. After all the tool-marks have been removed and a smooth dead surface free from scratches has been produced, it is ready for the next step.

The surfacing is continued by the use of brush wheels revolved in the lathe, charged with extra fine pumice-stone mixed with olive or lard oil. These wheels are of various shapes and sizes, as shown in Figs. 391, 392, 393, and 394. Carefully go over the case, revolving the lathe with moderate speed and keeping the case constantly in motion. These brush wheels cut quite rapidly: if the work is held still for a moment, it is apt to cause a noticeable flatness. Always brush to accommodate the hollows, and let the prominent points take care of themselves. This brushing is continued until all the fine scratches made by the Scotch stone have been removed and the case presents a dead-smooth surface. Any points that the brush wheel cannot reach are gone over with a soft piece of wood of suitable shape charged with pumice-stone and oil. Then with a stiff brush carefully wash the case with warm water and soap, using a little washing soda, so as to thoroughly remove the oil, etc. Wipe it dry with a soft towel, and go over it again with a softer brush wheel charged with tripoli or rotten-stone, using either dry. In this part of the process the lathe may be turned much more rapidly: a high rate of speed is rather an advantage. This produces quite a polish, but is not final. The case is again carefully washed as before, and if of gold the final polish is given with fine jeweller's rouge, mixed to a thin paste with alcohol, applied with a fine soft bristle-brush revolving rapidly in the lathe.

FIG. 395.



Upper Denture ready for mouth.

For the final polish in silver cases I prefer whiting or prepared or precipitated chalk. Rouge is apt to give them a slightly yellow color. The brush wheels used for oil and pumice should not be used for any other purpose, and should be put away and the lathe mandril wiped clean before using the rotten-stone. The wheels used for the final polish require especial care to keep them free from grease and grit.

The final polish is not merely for show: it produces a surface that is much easier to keep clean than the dead-smooth surface that precedes it. The case shown in Fig. 395 is now finished and ready for the mouth.

Adjusting the Finished Denture in the Mouth.

Full plates, if the models have been accurate, rarely require much adjusting when they are first placed in the mouth: not unfrequently, however, they may require a little attention before the patient is finally dismissed. The plate, although it fitted the mouth comfortably before the teeth were added, may now be found to extend too far over the alveolar border or may press upon the fræna of the mouth so as to cause pain or discomfort, and may require "easing" at these points, either at the time it is placed in the mouth or, more frequently, after it has been worn and used in mastication for a few days or a few weeks.

If the suction of an upper denture is defective, examine the back edge of the plate to see that it fits the roof of the mouth closely; if the palate is soft and yielding, notice if there is any space between the roof of the mouth and the plate during the act of swallowing. If there is, reduce the size of the plate so that its back edge will rest upon the more fixed portion of the palate, or bend the edge of the plate with the pliers so that it will press more firmly against the roof of the mouth. This edge of the plate occasionally requires adjusting, either to make it fit closer or to relieve pressure upon the hard palate. Either defect may be caused by conditions of the mouth not shown on the plaster cast and not easily anticipated. It is not necessarily evidence of an inaccurate cast or an imperfectly-fitting plate. Occasionally the suction may prove too strong and the edge of the vacuum-chamber press so hard as to cause pain; in such cases the edges should be rounded off with a file and smoothly polished.

The articulation usually requires adjusting: some points of the teeth may be a trifle too long, or the teeth of one side may strike harder than those of the other: this may occur without the articulating model being in fault. Until the teeth are securely fastened to the plate, so that the patient can close the jaws firmly, it is almost impossible to get a perfectly natural articulation; so that trifling differences, which are readily altered by the grindstone, between the articulation of the teeth on the model and in the mouth are to be expected. The points of the teeth may require adjusting to allow a little play to the lower jaw, so that the teeth will articulate fairly well if it is slightly protruded or retracted or to allow a little side motion. Occasionally the patient may complain of biting the cheek; this usually remedies itself: the muscles of the cheek become accustomed to the presence of the teeth, and are in a measure relaxed. Where it is persistent, remove sufficient from the buccal cusps of the teeth in fault, so that there is a slight space between them when the jaws are closed; this may be done without impairing their usefulness for mastication. Generally the last molar is most in fault, and it is no disadvantage to make this a trifle short.

After these practical points have been attended to we may consider those, scarcely less important, concerning the appearance only. If the patient is advanced in years grind off the points of the cuspids and the bicuspids, so as to make their cutting edges more nearly resemble the natural teeth at that age; and also in some cases it is well to pass the

grindstone over the cutting edges of the anterior teeth, especially of the lower denture, to give them the square edge usually seen in natural teeth after many years' wear. This should be done with judgment, and only when these changes are in harmony with their general appearance. Edentulous or nearly edentulous mouths are seldom straight. The changes following the loss of the teeth seem to impair the co-ordination of the surrounding tissues: one corner or angle of the mouth may droop, or when the mouth is opened the lips of one side rise higher than the other, etc. This may give the teeth the appearance of being too long on one side, although they may be perfectly level. A very little taken from the extreme point of a tooth may correct this and improve very much the appearance of the denture.

This removal of the cutting edges of the teeth, either to make a more useful articulation or to give a more natural expression, may be, and often is, done while arranging the teeth. I prefer to leave it until the case is finished, as there is always a liability of the teeth slightly changing their position during soldering—so slight as to be practically immaterial, and yet sufficient to impair the accurate adjustment of the teeth. I also think that the changes needed can be better seen and more satisfactorily made after the plates have settled to their place and the patient has become somewhat accustomed to their presence. Quite frequently the patient will complain of the gums being too full or the teeth too long when they are first inserted, but in a few days these apparent defects entirely disappear. The patient becomes accustomed to the changed appearance, the surroundings of the mouth accommodate themselves to the changed condition, and the plate settles to its proper position.

Partial dentures, especially when the remaining natural teeth occupy abnormal positions, frequently require considerable careful fitting when placed in the mouth, although, theoretically, a denture carefully fitted to a perfectly accurate cast should require none. Unfortunately, perfectly accurate casts exist only in theory: the most accurate cast attainable conveys no idea of the character of the surfaces it represents, whether they are yielding or rigid, neither does it give any idea how far the denture fitted to it will harmonize with its surroundings, nor yet enable us to see the case as it will be seen when in the mouth. By closely observing the mouth we may be able to judge how far the cast is reliable as a guide and make allowance for its unavoidable defects. So great is the variety in partial dentures, and so varied are the difficulties encountered in adjusting them to the mouth, that I can only refer to a few of the more notable and suggestive. Simple cases, if carefully made and if due care has been observed not to injure or deface the plaster cast, usually require but little else than easing undue pressure upon the gum and accurate adjustment of the clasps and the articulation. Cases where the remaining natural teeth occupy abnormal positions, where there are a number of scattered teeth, etc., often tax our skill and patience to the utmost. In this connection I cannot enforce too strongly the importance of not breaking the teeth from the plaster cast. Some think this a small matter, and even recommend that they be broken off to simplify the construction of the denture, contending that they can

be accurately replaced and securely held with cement when needed. This is a great mistake. They may be replaced *nearly* to their former position: the cement used to hold them, by its presence upon the fractured surfaces (even in the most favorable cases), prevents absolute accuracy. Quite frequently, however, they are so far from their former positions as to cause a great deal of extra labor in fitting the finished case in the mouth. Breaking teeth from the cast introduces an element of uncertainty a careful workman will always avoid.

In adjusting complicated cases, especially those of the lower jaw where the remaining teeth lean in various directions, and where it is very important that the denture should fit firmly, proceed slowly and carefully. Some cases whose adjustment seems at first sight hopeless readily slip in place with a little judicious manipulation: a little turn or twist to accommodate a leaning tooth, or a slight pressure, may move the teeth sufficiently to allow the plate to pass over them. A case may go in very hard, and exert so much pressure against the teeth as to be decidedly uncomfortable if not painful, and yet in a few hours or a few days may fit snugly and comfortably and be removed and replaced with ease. Probably the same case made to fit comfortably at first would ultimately prove a failure. By placing it in the mouth in a nearly vertical position, when inserting a partial lower denture for a cast like Fig. 352, so that it will pass under the remaining molars which lean forward, it will usually slide in place without difficulty, fitting against them accurately and leaving no space for lodgment of food, etc. between the natural and artificial teeth. Where the teeth on each side of a space to be supplied lean toward each other it is frequently desirable to place a tooth or teeth between them much wider than will pass between the narrow space at the cutting edges, so as to avoid the unsightly space on either side at the gum. In these cases we may make the teeth a little wide and depend upon the artificial teeth wedging the natural teeth apart, or when fitting them in the mouth a little may be removed from the side of the natural teeth near the cutting edges to make their sides more nearly parallel, or both expedients may be adopted in extreme cases. Fitting the artificial teeth somewhat tightly between the natural teeth at times not only assists in holding the plate firmly, but is frequently useful in supporting and prolonging the usefulness of natural teeth. In fitting suction cases, however, care must be taken that pressure against the natural teeth does not displace the plate and destroy the suction. When a partial case does not go in place readily, carefully examine it and the mouth before making any alterations, so as to see where it really binds. The real fault is not always where it seems to be, nor is it always readily seen. Proceed cautiously, remembering that while it is always possible and easy to remove portions of the teeth or plate, it is quite another matter to replace that which has been removed unnecessarily. In adjusting the length of the teeth bear in mind that they nearly always become shorter after a few days' use: this is especially true of the front teeth; sometimes they sink down to a very marked degree. Also remember that the natural gum nearly always recedes under pressure; therefore, let the artificial teeth press upon the gum firmly. The appearance of plain teeth resting upon the natural gums either in par-

tial or full dentures changes very much after a little use. When the case is first inserted perhaps only a few teeth touch the gum; in a short time they not only press upon it firmly, but this pressure causes the gum to rise into the interspaces, giving the teeth a very natural appearance. The cutting edges of the teeth frequently require a slight change in shape to give them a more natural appearance; the changes needed are usually self-suggestive to a careful observer, and have been referred to in the remarks upon selecting and arranging teeth for partial dentures. The final adjustment of the clasps is usually left until this time: referring to the remarks upon fitting clasps previously made, I can only add that they should be made to fit closely, but not tightly, and special care taken to make the ends lie close to the teeth, so as to not irritate the tongue or cheeks. The clasps should be made to *fit*, not to *bind*, and the plate so adjusted that it may be readily removed and replaced.

Always smooth with very fine sandpaper those portions of the teeth which have been ground in adjusting the case to the mouth, and where the bicuspids or molars have been ground smooth and flat on the masticating surface with a corundum disk cut narrow grooves across the crown to restore the roughness and make them more efficient in mastication.

Occasionally patients complain of full dentures "chattering," or striking together during mastication, so as to make a noticeable and disagreeable sound. This may be caused by malarticulation or by the upper denture not being retained with sufficient firmness, or the lower denture may be displaced by the muscles of the mouth, etc. Carved blocks are more liable to it—probably on account of their solidity, the teeth being so nearly in one piece. Occasionally, however, it is complained of where there is no assignable cause. It is a difficult matter to correct: in many cases it disappears as the patient becomes accustomed to the plate; in a few it is persistent and proves a serious annoyance in using an otherwise successful denture.

After the final adjustment of the finished denture to the mouth the patient should receive proper instruction in regard to the care and management of the appliance. The importance of cleanliness cannot be too strongly enforced, especially when the plate is retained by clasps. The plate should be removed and cleansed after each meal in all cases, and clasped teeth should receive special care. I do not advise wearing plates at night; a few hours' rest and the free access of the saliva, etc. to the mucous surfaces covered by the plate, removing from them effete matter, assists in keeping them in a normal and healthy condition. The patient should be impressed with the importance of prompt attention to any injuries inflicted upon the soft tissues of the mouth by the substitutes, as much future trouble and annoyance, if not permanent mutilation of the parts, may result from neglect, while such results may be readily averted by timely removal of the sources of injury.

The wounds made by pressure of the plate or by the edge of the plate or of the artificial gums pressing into the soft tissues usually heal very quickly after the cause of the injury has been removed: in cases where they do not, pulverized nitrate of potassium, applied with the moistened finger, gives prompt relief.

The patient should be cautioned that it takes some time, especially with full or whole dentures, to become accustomed to and to use them effectively. There is a great deal for the patient to learn after the dentist has done all that he can do. The tendency to displacement in upper dentures can be obviated in a measure by care in using them. In the effort to divide food with the front teeth the substance should be pressed backward and upward against the cutting edges of the superior incisors at the same time that the opposing teeth are closed upon each other. In the mastication of food the tongue should distribute as equally as possible portions of food to each side of the mouth, and in this manner divide the force applied, thereby lessening the chances of lateral displacement. It is recommended also that the tongue be pressed against the back edge of the plate when the front teeth are used, not only to support the plate by the pressure exerted, but by its presence to prevent the suction from being broken by a slight displacement of the plate.

Patients usually experience an awkwardness in beginning to wear artificial dentures that requires considerable encouragement and patience to overcome: little suggestions like the above will often prove valuable.

Warping or Springing of Plates during Soldering.

Soldering the teeth to the plate is the most trying ordeal through which a denture on gold or silver base has to pass. The operation occupies but a few minutes, but they are minutes of far more anxiety to the workman and of risk to the denture than is felt or incurred during all the rest of the work upon it combined. Warping of the plate is perhaps the most serious and vexatious mishap that ordinarily occurs during soldering: the fracture of a few teeth is easily repaired, but to refit a badly-warped plate is a difficult, and often at best an unsatisfactory, task.

The cause of this change or apparent change in the form of the plate, as was suggested when treating of constructing plates, frequently—or perhaps, more correctly, most frequently—antedates the operation of soldering. It may be the result of either defective dies or of incomplete or unskilful swaging. If the plate when finished fits the model tightly, binding upon the more prominent points, a slight pressure will force it into position, owing to the elasticity of the plate, and it *seems* to fit; but when the teeth are soldered, the solder and the backings of the teeth make the plate quite rigid: it no longer yields to pressure, and cannot be forced upon the cast, as it could before. Such cases are no doubt quite common. The inaccuracy in the fit may have existed when the plate was tested in the mouth: the same carelessness which failed to notice it upon the model would be quite as likely to overlook it there, especially if the patient had ,been requested to exhaust the air from beneath the plate as soon as it was inserted and before its adaptation was critically examined. This binding upon the alveolar border, however, is not always so serious a defect as the appearance of the denture upon the model would indicate. If the tissues of the mouth are yielding, it may prove an advantage.

The most serious cases of warping during soldering are caused by the

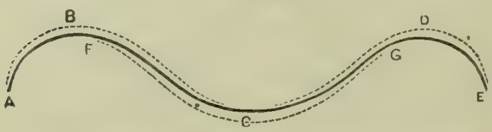
unskilful application of heat, the plate being made so hot that it is, to use a laboratory expression, "blistered" or "burned;" that is, fused upon the surface. In such cases the plate is raised from the investment, and may be distorted to a very great degree. This is more liable to occur with silver than with gold, and with silver produces brittleness and entirely destroys its texture. I consider this rather the result of carelessness than an accident: it is entirely avoidable, but if any considerable extent of the plate is involved it is irremediable.

Among the accidental causes, warping or fracture of the investment is the most common. One of the methods most frequently suggested to avoid warping the plate is the use of as little investment as possible. Some recommend the use of boxes of thin copper or iron to hold the investment together, so as to permit of a smaller amount of investing material being used, the case being placed in the box much in the same manner in which a case is flasked for vulcanizing when the teeth and plate are in the same part of the flask.

This plan is directly opposed to all my experience. If the investment has but little substance or body, especially if it contains a large proportion of plaster, it is liable to warp or change its form when highly heated, not on account of fusing or becoming plastic by heating, but on account of innumerable fine cracks throughout its substance caused by its contraction. The use of copper or iron boxes would not prevent this in the slightest degree; they would simply prevent its falling apart. The investing material, as previously recommended, should contain as large a proportion of sand, thoroughly mixed with it, as the plaster will bear without becoming too friable to hold together while the case is being prepared for soldering. A small portion of pulverized asbestos gives it toughness, but not more than a tablespoonful can with advantage be added to the amount of material required for investing a full upper denture; if more is used it makes the investment soft and friable: the toughening effect of the asbestos is not noticed until the case is highly heated. About five or six parts of sand to four of plaster will give satisfactory results, and the investment thus composed may be used of sufficient thickness to prevent accident in handling and soldering, an iron or copper wire being imbedded in it, as previously recommended, just outside and near the cutting edges of the teeth, to hold it together in case it should crack during soldering. Any change in the form of the investment, either from contraction or fracture, necessarily changes the shape of the plate imbedded in it.[1]

[1] *Springing of Plates in Soldering.*—Why does a plate spring in soldering? Case it up in the ordinary way in equal parts of sand and plaster. It is now imbedded below around the entire edge and externally at the sides in a hard, resisting mixture. Bring on the heat, and what changes of shape *must* it undergo? A glance at the diagram will show us at once. The dark line represents the edge of a transverse section of a plate between the bicuspids in its normal position. The points A, C, E, being fixed by the hard casing, the plate when expanded by heat will assume the position indicated by the upper dotted line. While in this dis-

FIG. 396.



Method of preventing plates warping during soldering.

If the warping is caused by the plate expanding more than the investment, and by its being rigidly held by the investment at some points, and thus forced to change its form or shape, the distortion thus caused being made permanent by the solder flowed over and the backings, etc. united to it, as some writers contend, the assigned cause being a constant one and present in every case, it naturally follows that no case could be soldered without being warped. This is by no means the case. In the hands of careful workmen warping of plates to a noticeable degree during soldering is quite exceptional.

Next in importance as a cause of the warping of plates I have found jointing the gums of gum teeth too tightly. The precaution of placing a piece of paper between the teeth to avoid this should always be observed.

The warping of plates during soldering has been most thoroughly discussed in the past, and many theories and explanations regarding the causes, and the manner in which they produce the results, have been given. There is no doubt that, as claimed by most writers, the expansion of the plate, the firm union of the backings and the added solder, and the effect they have upon the contraction of the plate as the mass cools, may change its form to a slight degree, but ordinarily so slightly as to be unnoticeable. The causes I have enumerated I consider to be more potent and to practically cover the whole ground.

The change usually noticed when a plate has warped is in the nature of a contraction : an upper plate will bind upon the outer surface of the alveolar border or rock upon the centre of the palate ; lower plates are usually drawn in at the condyles, so that the extreme ends or heels of the plate are drawn closer together. Partial plates do not usually change their form to any appreciable extent unless they approach a full denture in the number and arrangement of the teeth. It is not uncommon, however, for the edge or border of the plate that fits around the teeth to rise up from the cast, especially if a stiffening-piece has been added too closely to the edge; the stiffening-piece should always be placed a little distance inside the edge, not only to avoid this, but to permit the edge to be more readily refitted in case any change should occur.

Refitting partial plates is usually a simple matter. It is seldom that the shape is materially changed, unless it has been overheated or some unusual accident has occurred. If the edges of the plate are raised from the cast, they are usually refitted with the pliers or by judicious manipulation with the small bench hammer while the plate is firmly held in

torted shape the solder at B and D flows, sits firmly, and effectually prevents a return to the original position. This will sufficiently illustrate the *cause* of springing in every other part of the plate.

To remedy this difficulty a very simple expedient only is necessary. After the teeth are fully arranged melt some *clean* beeswax in a spoon, and with a camel's-hair pencil coat the plate over the whole lower surface to a line opposite to the linings of the teeth, leaving the surface between A F and G E uncoated. Also coat the *whole edge* of the plate, allowing the wax to extend on the outside a line or two upon the gums of the teeth. It is now ready for casing in the ordinary way, It is evident that when the heat is brought on the wax will melt and allow the plate to expand downward at A, C, and E, while the points B and D will remain stationary very nearly. On cooling the plate will assume its first shape (J. F. Leaming of Seaville, N. J., *Dental Cosmos*, vol. ii. p. 374).

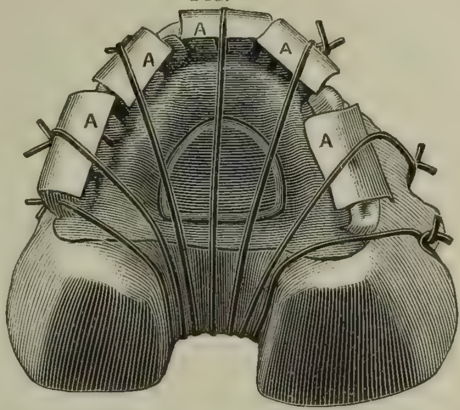
place upon the plaster cast; care is required, however, in these manipulations to avoid any strain upon the teeth. If they fit firmly against the plaster cast, it is better to first scrape the plaster away until they barely touch. It is well to remember, also, that a tooth may be shattered by the jar communicated to a plate by a sharp blow with the hammer, although the tooth is quite free and at some distance from the point where the blow is struck.

Refitting full dentures for either jaw is a much more difficult task. With plain teeth the difficulty and risk are far less than with gum teeth. If the mishap has been caused by the gums being too closely jointed together, it is almost impossible to overcome the misfit without fracturing some of the teeth. The manipulations necessary in refitting a warped plate are so nearly like those suggested for fitting a plate after swaging, modified of course by the presence of the teeth, that I do not consider it needful to do more than refer to the remarks upon this subject. By practice and experience a skilled workman acquires a knack in fitting plates: a little bending with the fingers or the pliers or a few taps with the hammer bring about a marvellous change either in the simple plate or the nearly-finished denture. This is acquired only by practice; it cannot be described or taught. In these cases first ascertain the exact locality of the fault, and then study out the best method of correcting it. Do nothing without having a definite object in view. By closely observing these rules, in course of time the mind and the fingers, the perceptive and constructive faculties, become so thoroughly drilled in these special manipulations that they are performed instinctively and apparently without effort.

By careful manipulation in some cases the general fit is made fairly satisfactory, but there still remains a rock or spring which, although slight, is yet sufficient to seriously impair the usefulness of the denture. This may be overcome by the following procedure, technically termed "tying down:" if properly performed upon a hard, unmutilated cast, this operation always produces an accurate fit, provided the plate accurately fitted the model before soldering: If the case is a full upper denture, first, to protect it from injury when the case is heated, partly fill the vacuum-cavity with plaster mixed thin, and place the case upon the plaster cast; it is immaterial whether this is done immediately or after the plaster placed in the vacuum-cavity has set, provided the plaster is entirely confined to the cavity and does not prevent the denture from going to its place. Then, holding the denture firmly to the cast, cut a mortice in the back part of the cast quite to the edge of the plate for a distance of about half an inch on each side of the median line and extending from the face to the bottom of the cast, leaving the edges quite square, as seen in Fig. 397. The object in this operation is to bind the case to the cast with binding wire, so arranged that when the ends of the binding wire are twisted together the case will be drawn tightly to the cast; the wire is intended to impinge upon the plate at the back part, so as to hold or draw it to the cast. The mortice is cut to allow this, and where the wire passes over the teeth at the median line and at the sides a V-shaped groove is made in the side of the cast sufficiently deep to give the wire such a direction that the force exerted by it will

be transmitted through the teeth and tend to press the plate at that point firmly to the cast. If no groove were made a properly-shaped cast would hold the wire in such a position that the force exerted through it would tend to bend the teeth out rather than press the plate to the cast. Usually seven wires are used, located as follows: One on the median line, passing around the denture and the cast in the following manner: Beginning at the front of the cast, passing under it, up in the centre of the mortice just referred to, impinging upon the back part of the plate at its centre, passing over the palatal surface of the denture in a straight line from the edge of the mortice to the cutting edges of the central teeth, and resting over the interspace between them; thence to the point of beginning, where it is cut off, being left sufficiently long to permit the ends being twisted together in such a manner that at a subsequent stage they may be grasped with the pliers and the wire tightened by still further twisting them. In a similar manner on each side a wire is passed over the heel of the plate just back of the last molar, it being prevented from slipping off at the back part of the cast by the edge of the mortice, and in front by a groove cut in the base of the cast sufficiently forward to hold it securely in place. Another in like manner is passed obliquely over the molar teeth, and another rests between the first bicuspid and the cuspid teeth of each side. Fig. 397 represents the case with the wires in position. These positions may be varied somewhat to meet the requirements of the case. In tying down a lower denture, instead of cutting a mortice in the back part of the cast a large hole is cut in the cast, through which the wires are passed, locating it and making it funnel-shaped, with the small orifice opening upon the bottom of the cast, so that the wires will take a proper direction to draw the denture firmly to the cast. The wires are located substantially in the same positions as for an upper denture, but are not made to impinge upon the edges of the plate: they pass over and impinge only upon the cutting edges of the teeth.

Fig. 397.



Method of refitting an upper denture warped during soldering by "tying down:" A, brass caps to protect teeth.

Before placing the wires in position the teeth over which they pass are protected by caps made of sheet brass, about No. 22, bent to fit over the cutting edges loosely and made long enough to rest upon several teeth, as shown at A, Fig. 397. These are filled with plaster and placed in position, they being so firmly pressed upon the teeth that the brass rests upon them solidly, the plaster simply filling the space between the caps and the teeth that would otherwise be vacant. It is important that the brass should rest solidly upon the teeth; if there is any thickness of

plaster between the caps and the teeth, it is crushed as soon as the wire is tightened, not only delaying the operation, but causing the pressure to be unevenly applied; it also increases the risk of the ends of the wire twisting off, as will be presently explained.

When the caps are in place, without waiting for the plaster to set proceed to adjust the wire, using for this purpose tough, annealed iron wire, No. 18. I think it is best to adjust the central wire first, and then those over the heel of the plate on either side, and lastly those over the molars and between the bicuspids and the cuspids, drawing them sufficiently tight to barely hold in place; after they are all adjusted, tighten them so as to spring the plate to the cast, having first noticed which wires will most readily do this, and twisting these tight first. This point requires careful attention: in most cases some one or more of the wires will readily draw that portion of the plate that springs from the cast into position, while perhaps some other wire will have an opposite effect. In badly-warped cases this tightening must be done cautiously; it may be impossible to at once draw the plate into contact with the cast without applying so much force as to fracture the teeth. It is desirable that the wire should be twisted as tightly as consistent with safety before the case is heated, as the case while cold can be handled so much more readily. In adjusting the wires keep the points where they are twisted together sufficiently far from the teeth that the necessary manipulation will not interfere with the plaster presently to be added for their protection; also keep this point as nearly in line as possible, and twist all the wires in the same direction. If this is neglected, and some are twisted in one direction and some in another, it is very probable that at the critical moment the direction in which they are twisted may be overlooked, and the wire be inadvertently loosened instead of being tightened.

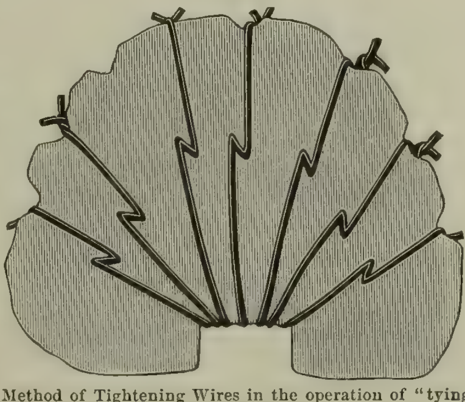
After the wires are adjusted place over the face and cutting edges of the teeth a coating of plaster about a quarter of an inch thick, and a much thinner coating over the backings. While it is desirable that the teeth should be thoroughly protected from direct contact of the blowpipe flame, it is also desirable that as much as possible of the surface of the plate should be exposed, so that it can be thoroughly and uniformly heated. When this plaster is hard we are ready to proceed to the critical part of the process: before doing so, however, it may be best to explain the object we have in view and the manner in which this process brings about the desired result. All metals become more pliable when they are heated to a degree approaching their fusing-point. This fact is utilized in the process we are considering. In the first place, the plate is firmly bound to the cast; its tendency to spring away from it is overcome by the force used in drawing the wires tight. It is now purposed, while it is in this condition, to heat it to a degree at which the metal of which it is constructed loses its elasticity, and while it is thus heated the wires binding it to the cast are drawn still tighter by twisting their ends together; this alternate heating of the plate and tightening of the wires is continued until the plate is made to fit the cast at all points; it is again heated to fix it in this position, and is then allowed to cool. The contraction of the wires, which were drawn tight while they were hot and

expanded, may also help in bringing about the desired result, but indirectly and to a very slight degree. The plaster cast is of course destroyed: it may be somewhat hardened by applying to it several coats of varnish as soon as the case is removed. When the operation has been successfully performed the plate fits quite as accurately as it did before soldering.

Before beginning to heat the case have close at hand a thick cloth, slightly damped so that it will not readily take fire, with which to protect the hands while handling the case (a thick woollen glove on the left hand may be used instead); also two pairs of pliers with sharp flat beaks with which to grasp the ends of the wires: the second pair is needed, as frequently one pair becomes too hot to be conveniently handled. Place the case on the soldering support, and with a broad flame from the blowpipe directed upon the plaster about the teeth slowly and evenly heat the case; gradually extend the flame over the plate until it is thoroughly red hot. Now grasp the cast with the left hand, and with the pliers in the right rapidly yet deliberately twist each wire in succession, endeavoring by twisting each a little at a time to bring them all to a uniform tension. Again heat the case, increasing the heat a little—in fact, making the exposed portion of the plate as hot as it can be without roughening the solder—and again tighten the wires as before. I usually repeat this a third time before setting it aside to slowly cool.

There is a knack in twisting the wires without breaking off the ends: two wires may be twisted together indefinitely without injury. In the operation we are considering, however, after the wires have been drawn tight, there is a tendency for the ends of the wires to get into such a position that one is wound upon the other instead of the two being twisted together; the torsion upon the one, acting as a mandril, soon twists it off. To avoid this, first bring the ends of the wire together tightly, so as to have as little twisting to do as possible; and secondly, after grasping the wires with the pliers pull them straight out from the cast before rotating the hand, so as to draw them equally tight, and as they are twisted together allow them to approach the cast; in this way this tendency may be in a measure overcome, but it is difficult to entirely avoid it if there is much twisting to be done. After the wires have been twisted as tightly as possible they are still further tightened by grasping each in succession with the pliers at about the centre of that portion passing across the bottom of the cast, and by rotating the pliers bending the wire upon itself, as shown in Fig.

Fig. 398.



Method of Tightening Wires in the operation of "tying-down."

398. Repeat this also upon the portion laying in the mortice at the back of the cast. Provided that the warping of the plate is not due to the gums of the teeth having been jointed too tightly, the risk of injury to the teeth, if the operation is carefully performed, is exceedingly slight.

This process is not applicable to partial cases when the teeth are scattered, and is less effective in lower cases, especially if the alveolar ridge is narrow.

Rimming.

The addition of a rim to dentures of single gum or block teeth—that is, a gold or silver band upon the border or edge of either an upper or lower plate to receive the gum extremities of the teeth—adds very much to the strength and artistic appearance of the denture.

This can be added only in cases where the plate extends beyond the gums of the teeth, and where the lip is sufficiently long to prevent its being seen when the mouth is widely opened and the lips retracted, as in laughing, etc. Rims are not confined exclusively to full dentures; they may be applied to either upper or lower partial cases where there are a number of single gum or block teeth together. If the work is well done, rimming makes a neat finish to the case, the thick rounded edge is more comfortable to the mouth, and the rim, covering the joints between the plate and the teeth and being burnished closely to them, prevents the lodgment of food, etc., and thus adds very much to its cleanliness. Rimming also materially strengthens the denture, not only by the amount of gold or silver added to a weak part of the plate, but also by forming a groove or socket in which the ends of the teeth rest, protecting them from injury and assisting the platinum pins, especially of the molars and bicuspids, in resisting the strain of mastication.

When carved block teeth are to be used it is far better to solder the rim to the plate before the blocks are made: the presence of the rim gives the block-carver but little more labor in moulding and fitting his work, while the labor of adding it to the plate after the teeth are made is far greater and has no practical advantage.

Rimming a plate before the teeth are carved or fitted to it is a very simple matter. It is done immediately after the plate has been adjusted to the mouth, the articulation secured, and the articulating model made. The wax used in taking the articulation, giving also the intended fulness of the gum, indicates the width of the rim. In locating the position of the rim two things are to be considered: first, the probability of the border of the plate extending too far over the alveolar ridge; and second, the probability of the rim being seen when the mouth is widely open. Provision must always be made for reducing the size of the plate without injury to the rim should its border press too firmly upon the soft tissues. To this end the rim is located a little inside the outer border of the plate, but not so far as to be exposed in laughing, etc.; and in soldering it to the plate the solder is allowed to run into and fill the apex of the angle between the rim and the plate. In constructing such a rim take two strips of plate—about No. 26 American

standard wire gauge—the width of the intended rim, and each strip long enough for one-half of the rim. It is possible to make the rim in one piece, but is seldom convenient to do so. After cleaning all wax, etc. from the plate and filing one end of a strip to a bevel, so that the two halves may be neatly joined, begin with the bevelled end of the strip at the centre of the plate, and carefully fit about half an inch of the strip so that one edge touches the plate and the other stands out from it at an acute angle, forming a groove or socket into which the teeth are to be fitted. This may be held in place for soldering with binding wire, or it may be held with cement and plaster be afterward added to hold it while being soldered. Then "tack it"—that is, flow a little solder so as to unite the rim and the plate for a portion of the distance they have been fitted: the object is to firmly unite them at one point, so as to facilitate fitting the remaining portion of the rim, and yet not joining them so solidly but that the position of the rim may be changed to correct any error that may have been made.

In an upper denture the gum end of the teeth necessarily ends more or less abruptly, forming an objectionable projection. If the gums are bevelled off to remove this, they soon become broken and chipped on account of their extreme ends being made so thin and weak: to avoid this they are usually simply rounded with the grindstone, without reducing to any great extent their abruptness. One of the functions of a well-arranged rim is to avoid this and make a smooth, unbroken surface from the extreme edge of the plate to the gum portion of the teeth. This should always be borne in mind in fitting a rim to a plate: it should never stand out from the plate abruptly, but should be wide enough, and commence sufficiently far from the gum end of the teeth, to avoid doing so. The strip being tacked, it may be bent in or out until it stands at the proper angle to the plate. Then proceed to adapt the remaining portion of the rim, bending it with the fingers or the pliers until the edge to be united to the plate fits closely as far as the teeth will extend; do not cut it off at this point, but leave it sufficiently long to extend around the last molar and connect with the backings. If the strip requires bending sideways, this is readily done by laying it on the small anvil and with the blade of the bench hammer forging out either edge as may be required. When the rim is fitted it is held in place with binding wire passing around the plate, but not pressing so tightly as to bend it. It is not necessary to twist it tightly if it is properly used. After passing it around the plate and rim, twist the ends together, and then with a graver or the pliers bend the wire over the rim into a fold, the wire being doubled on itself with the rim between. By this means we not only hold the rim to the plate, but also, by bending the wire where it is folded, can securely hold it in the required position. It usually requires two or three wires at as many different points to hold it well in place. Then solder it about as far as the middle of the last molar: the end is to be left unsoldered until the teeth are carved. Owing to the contraction of the porcelain in baking, it is impossible to mould and carve block teeth to fit that portion of the rim extending around the heel of the plate; it is therefore left to be adjusted and soldered after the teeth are carved and before the case is invested. If care

is used not to allow the wire to bend the plate, and to let the plate rest solidly upon the support during soldering, the rim can be soldered all round without investing and with but little risk of the fit of the plate being impaired. After one side is complete proceed to arrange the other in the same way, being careful to unite them neatly at the median line. Lower plates are rimmed in the same way: they are usually much easier to do, as the strip may be long enough to form the entire rim. If the mouth is flat, half-round wire may be used to advantage; it can be bent with more facility than plate, and makes a neat rim.

Some prefer to fit the rim to one side of the plate, and, holding it in place with cement, invest it for soldering in a mixture of equal parts of plaster and sand, building the investment over the rim to hold it securely in place. When one side is soldered the other is arranged in the same manner.

Among other methods which have been recommended for forming rims upon plates before the teeth are arranged, we may mention that of preparing the plaster cast and dies in the manner usual in constructing plates for continuous-gum work, so as to swage the rim in one piece with the plate. This is not only tedious, but objectionable from the fact that no change can be made to the outer border of the plate to relieve excessive pressure upon the soft tissues without filing the rim away at that point. Another method is to place wax upon the plate and carve it to represent the gums of the teeth, from this either making metallic dies to swage the rim or reproducing the wax in plaster, fitting the rim to this and holding it in place with binding wire until it is soldered. The method described in detail I have found the most rapid and practical.

These methods are not suitable when the block teeth are carved before the rim is constructed or where single gum teeth are used; it is practically impossible to fit the gum ends of the teeth to the rim and make a neat piece of work. No amount of skill or care in fitting the teeth to the rim separately will prevent an unevenness in the length and bevel of the gum, which impairs very seriously the appearance of the work. In these cases the rim must be fitted to the teeth, and not the teeth to the rim.

Many varied methods have been suggested from time to time for constructing rims where single gum teeth are employed, and for block teeth where the rim is constructed after the teeth have been carved; many, however, have proved either too cumbersome or altogether impracticable.

For many years I invariably rimmed these cases after the teeth were soldered to the plate: in doing so there is a slight risk of shattering the gums during soldering, but with care in investing, in applying the borax, and in soldering, accidents seldom occur. When this method is followed, after the case is soldered and cleaned by acid, and before commencing to finish the backings, carefully wash to remove all trace of acid, and then grind the gum ends of the teeth until they conform to an even line from heel to heel of the plate, removing the rounded edge and forming an even bevel of a somewhat obtuse angle to receive the rim. It is important that the finished rim should fit with absolute closeness to the teeth

at its free edge; and, as it is more difficult to burnish it to a rounded surface than to a flat one, this should be borne in mind in preparing a case for rimming.

It is important also to have sufficient room between the ends of the teeth and the edge of the plate not only to solder the rim, but also to give it sufficient width to avoid making it too abrupt.

If the rim is narrow and of the same width from end to end, half-round wire, letting the flat side rest against the teeth, is usually to be preferred; if wide, or wide at some points and narrow at others, it is best to cut a paper pattern and make the rim of plate about No. 24 American wire gauge. Usually it is better to make it in two parts, each extending from the median line to the condyle of either side, overlapping a little at the median line to make a neat joint.

When preparing for soldering a case which it is intended to rim in this manner, a piece of plate should be fitted around the back part of each end molar, extending from the backing to as far round the molar gum as it can be soldered, and soldered in place at the same time as the teeth are soldered to the plate. This is intended to form part of the rim, and is fitted and soldered at this time on account of the difficulty of reaching that part when the case is invested for soldering the other portions of the rim.

The method of fitting the rim is the same for either plate or half-round wire. Begin at the median line, and carefully bend the plate or half-round wire with either the fingers or pliers until it fits accurately in place, bevelling each end so as to make a neat joint with the piece extending from the backings around the last molar at one end, and with the other half of the rim at the median line. It is hardly probable that it can be fitted so accurately as to rest solidly in place without springing somewhat, but it should so nearly fit that the binding wire simply holds it in place, and is not depended upon to hold it close to the teeth. If the fitting is imperfectly done and the rim is drawn close to the teeth by the wire, it may seem to fit accurately when invested; but when the case is heated for soldering, the binding wire, becoming hot before the rim, will expand and allow the rim to spring from the teeth, so that after it is soldered it will be a difficult if not an impossible task to bend or burnish it to fit as closely to the teeth as it should. After both halves of the rim are fitted as accurately as possible they may be held in place for investing with cement, or preferably with binding wire. For this purpose annealed iron wire No. 30 or 32 may be used: strength is of but little importance; there should be but little strain upon it. Before placing the rim in position paint the porcelain against which it rests with a thin coating of whiting and water or plaster and water, letting it also run in between the gums of the teeth and the plate, but carefully keeping it from any part upon which the solder is intended to flow. This is mainly to prevent the borax from coming in contact with the porcelain.

Place both halves of the rim in place, and pass a wire around the case in such a position as to impinge upon the rim on both sides—say between the bicuspids or the bicuspid and molar—passing it between the teeth or over the cutting edges as may be most convenient; twisting

the ends together so as to barely draw it tight enough to hold the rim in place; then, taking hold of the wire with the flat pliers, draw it sufficiently tight by bending it upon itself, as shown in Fig. 398. If the tightening is done entirely by twisting the ends, there is a great risk of changing the shape of the plate either while placing the wires in position or during soldering; by bending the wire as suggested sufficient strain is exerted to hold the rim securely, without the slightest risk of bending the plate; the wire, so bent, is not a rigid band around the case, but exerts an elastic pressure. Place as many wires around the case, in any direction most convenient, as may be necessary to hold the rim securely. If half-round wire is used for the rim, it should be wide enough on the flat side to reach from the plate sufficiently far over the gums of the teeth to cover the bevel made with the grindstone, but not to extend beyond this. Where it passes over slight depressions in the plate do not bend the wire to fit them, but depend upon fitting a piece of plate to cover the space.

When the rim is accurately adjusted in place, either with cement or wire, proceed to invest the case for soldering, using for this purpose the same mixture of plaster and sand as was used for investing to solder the teeth to the plate. First fill the lingual surface of the case with the sand and plaster to a level with the tops of the teeth; then invert it over a mass of the investment previously placed upon a piece of glass, pressing it down so as to leave about a quarter of an inch under the cutting edges of the teeth; then build it up outside of the teeth about half an inch thick, sufficiently high to thoroughly protect the gums and to extend a trifle over the free edge of the rim: build the plaster up quite wide at the top, so that there will be no danger of its burning away or cracking so as to expose the gums of the teeth. Build it up at the back part so that the posterior edge of the plate is well covered, and extend it over the palatal surface to a little beyond the margins of the vacuum-cavity. Be careful not to allow any of the investment to encroach upon any part where the solder is intended to flow, and make provision for soldering the rim far enough around the last molar to meet the piece extending from the backings.

When the investment is hard remove the cement if it has been used, and see that the surfaces to be soldered are clean. If binding wire has been used, do not disturb it. Apply the borax carefully and not too freely, and add sufficient solder to "tack" the rim at a number of points, and proceed to heat the case preparatory to soldering. When using the blowpipe to flow the solder avoid directing the pointed flame against that part of the plate immediately back of the gums of the teeth.

Endeavor to heat the case evenly, and after fixing the rim in position by fusing or flowing the solder first placed on the case, cut or break those strands of binding wire not fused or burned in two, and carefully bend the ends out of the way, taking special care not to displace the investment. Any portions of the binding wire held by the solder or borax, and not readily removed, may be allowed to rest until completing the soldering, when, if in the way, it may be pushed aside with the soldering-point. Then begin at one end of the rim and flow

the solder, adding enough to fill the sharp angle between the rim and the plate and to make a smooth, neat finish.

This method of rimming does not seem to be generally known and practised. It is more rapid than any other, and has the decided advantage that after the teeth have been adjusted to the mouth finally they are not again removed from the plate, as is the case in all methods of rimming after the teeth are arranged and before they are soldered to the plate. It requires careful attention to detail to avoid fracturing the teeth or warping the plate, but in careful hands is by no means as hazardous as might be supposed.

I have described the method for a full upper denture: the changes needed to adapt it to partial or to lower dentures will readily suggest themselves.

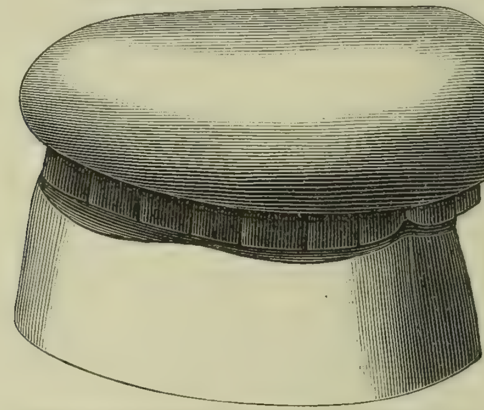
There are a number of methods in use for constructing rims to be united to the plate after the teeth are arranged and before they are soldered to the plate. The simplest perhaps is as follows: After they have been adapted to the plate, trace the outline of the gum portions of the teeth upon the plate with a sharp instrument; slightly warm the plate, so that the teeth and the cement may be removed bodily and laid aside with the least possible displacement. Clean the cement from the plate, and draw another line a little within the first all round, and fit and solder the rim to the line last drawn; remove the teeth from the wax or cement and readjust the latter in its proper place upon the plate; then fit each tooth separately to the rim by grinding away sufficiently from the end of the tooth to effect an accurate adjustment of it to the socket. The ends of the teeth may be ground away in fitting them to the rim until the platinum pins freely enter the rivet holes in the wax, thus restoring them to their proper position in relation to the base.

The objections to this method are—First, the accurate replacement of the wax or cement is a practical impossibility: the teeth may be replaced very nearly in their former position, but it would be unwise to complete the case without readjusting them in the mouth; secondly, when the teeth are fitted to the rim separately it is impossible to get the ends even as to length and bevel; and thirdly, the labor of replacing the teeth would be nearly as great as when they were first arranged.

I much prefer the following method. It has the decided advantage that from beginning to end the teeth are handled as though they were in one piece, and the chances of their position being changed is therefore much reduced; usually, however, with all possible care, there is a trifling lengthening of the teeth, owing no doubt to a slight change in the plate which prevents the plaster guide from fitting it as closely after the rim has been soldered as it did before. After the case is fully prepared for investing place it upon the plaster cast, having cut one or more cone-shaped holes or a vertical groove in the back part to serve as guides to readjust to the cast the model now to be made; and after preparing the surface of the cast so that the plaster now to be added will not unite with it, proceed to build plaster upon the case precisely as though making an articulating model, allowing it to slightly overlap the cutting edges of the teeth and to extend over the back part of the cast, so as to have a solid bearing. When this is hard, smooth the edge

immediately over the teeth, making around it a number of cone-shaped pits, and after properly preparing the surface of the plaster to prevent union, add plaster so as to extend over the face of the teeth as far as the gums, and to extend over the plaster model previously made sufficiently far to give it a solid bearing (Fig. 399). The object is to thoroughly

Fig. 399.



Guide to hold single gum teeth together while adjusting a rim.

imbed the teeth in plaster, so that in fitting the rim they can be removed from the plate, and be readjusted as though they were in one piece. This guide is made in two sections, so that if desired when the rim is finished the last-made section can be removed without disturbing the relation of the teeth, to permit of the case being invested in the manner presently to be described. When the sections are hard remove the guides and the case from the cast, and proceed to grind the gum ends of the teeth precisely as described for rimming after soldering the teeth to the plate: the plaster moulds hold them so securely in their position and in their relation to the plate that this can be readily and satisfactorily done. After this operation is complete we may proceed to form the rim in three different ways: First, by swaging, making the die for each half of the rim by moulding in sand directly from the case; or by taking a plaster impression of the parts to which the rim is to be fitted, and from this making a plaster cast to be reproduced in zinc by the usual method; or by taking this impression in a mixture of moulding sand and plaster or other material in which zinc can be cast. After the zinc die is made the lead counter-die is obtained in the usual manner. Then cut a paper pattern by which to cut the metal strip of which the rim is to be made. I would recommend that swaged rims be made to extend to the border of the plate; thus made, they are much easier to swage and to solder. There is usually a little difficulty in holding the strip in place upon the die when commencing to swage, and a constant liability of its moving out of position during that operation unless great care is used. When swaged proceed to trim it to shape. Usually, swaged rims are made to extend too far over the gums of the teeth: they should not extend farther than the bevel ground to receive them unless the gum

is very thin, and in no case farther than can be burnished down closely. The rim looks clumsy, without being any more useful, if made to extend farther over the gum. I do not admire "festooning" the rim—that is, scalloping its free edge and forming little points to extend over the joint between the teeth. It gives a great deal of extra labor, shows plainly any little inaccuracy in the festooning, and is of no practical use. A neat rim extending over the bevel only, with its free edge even and burnished closely to the teeth, is far more practical and useful than any fanciful arrangement I have seen.

After the rim is fitted to its position, the two halves being slightly bevelled and overlapping at the median line, so as to make a neat joint, and that part extending around the last molar adapted to make a continuous band to and uniting with the backings, it may be held in place for investing by shellac, or by a little plaster placed at several points, or by drilling several rivet holes on each side and riveting it in place. This latter method is by far the most secure if there is room between the gums and the edge of the plate for the rivets. The rivets are to be placed in the holes and tightened before the teeth are removed from the plate, so that there may be no risk of the rims changing their position during investment or soldering. Then slightly warm the plate by holding it over a Bunsen burner or the spirit-lamp, and remove the plate, leaving the teeth imbedded in the plaster moulds. The rim, having been fitted to the teeth, if carefully invested and soldered will fit them as well after it is soldered to the plate as it did before. The plate is now invested in the same mixture of plaster and sand as is used in investing teeth. If the rim is very shallow and does not extend much over the plate above the teeth, it may be well to paint the inside of the rim with whiting or plaster, mixed thin to keep the solder from filling it up; in other cases it is better that the solder should run in slightly, so that there will be no danger in filing through it if it should be found necessary to reduce the size of the plate: a little care in soldering will prevent the solder from filling the socket so as to interfere with the teeth.

By the second method, place the case on the cast and proceed to take a plaster impression of the parts to which the rim is to be fitted, allowing the impression to pass around the last molar as far as the rim is to extend, and to rest upon the front part of the cast sufficiently to permit of its removal and accurate replacement, the cast having been previously prepared to prevent the new plaster from uniting with the old. When the impression is hard remove it by inserting a thin knife-blade between the new and old plaster; it is seldom that its shape will permit its removal in one piece, but with a little care it can generally be broken away in but few pieces. Then remove the case, and after warming the plate remove it, leaving the teeth imbedded in the guides. Clean the adhering cement from the plate, and after replacing it upon the cast replace the impression, securing it in position with cement, and, after properly preparing it to prevent union with the new plaster, proceed to run plaster into it so as to secure a fac-simile of that part of the teeth to which the rim is to be fitted, allowing the plaster to extend over the lingual surface of the plate so as to give the cast sufficient strength. When this is hard remove the impression. We now have an accurate fac-simile of

the teeth, and proceed to adjust a rim to this in precisely the same manner as though the teeth were soldered to the plate, holding it in place with binding wire precisely as directed when describing that method, taking special care, however, not to draw the wire so tightly as to crush the plaster. The rim is soldered without investing.

By the third method the rim is fitted to the teeth themselves, as previously described, and held in place with shellac or plaster while the teeth are removed. The plate and rim are then invested for soldering in a mixture of plaster and sand, the investment being made to extend slightly over the free edge of the rim to hold it in place. It is seldom necessary to place whiting or plaster inside the rim to keep the solder from entering; the investment usually prevents its encroaching upon the space required for the teeth.

I consider this latter method by far the most practical. When time is no object and the workman not accustomed to fitting rims, or for specially difficult cases, swaging gives good results. Theoretically, swaging should give more accurate results than any other method, but practically there are so many difficulties encountered in constructing the dies, in keeping the strips of metal between them, in so arranging them that the impact of the blow will swage evenly the rim or that part of it between the dies—quite often, owing to its peculiar shape, a matter of considerable difficulty—that it is seldom practised by practical workmen.

When the plate and rim are invested, especially if the rim is held in place by plaster or cement, very great care is required to remove the cement and prepare the case for soldering without disturbing the rim or without removing so much of the investment that the rim will be displaced during soldering. It is better to scrape or clean the plate and the edge of the rim to be soldered to it before they are fastened together, so as to avoid the risk of their displacement after they are invested. The borax should be applied rather sparingly, and but little solder should be added to the case before heating it.

When the second method is adopted and the rim is soldered without investing, great care is needed in applying the blowpipe flame. Heat the work gradually and evenly; if the hot blowpipe flame strikes the rim, it usually causes it to curve up. The binding wire may be expanded by the heat, or may even be fused if the heat is unskilfully applied, and thus allow the rim to move from its position before the solder flows. To avoid this, put on a few small pieces of solder at intervals all around the rim, and after evenly heating the case begin by tacking or fusing them as rapidly as possible, and thus secure the rim in position. When this is accomplished begin at one end and leisurely complete the soldering, adding sufficient solder to fill up sharp angles and leave a smooth, easily-finished surface.

When the rim is invested always, before taking it to the blowpipe, heat the case as carefully and as hot as though teeth were to be soldered; and be careful not to apply a pointed flame to the rim until it has been tacked in position. While less likely to occur when the case is thoroughly heated, the rim is apt to spring or curve up if the flame of the blowpipe is directed upon it.

In all cases in soldering rims to plates before the teeth have been soldered do not solder the part extending around the back part of the last molar to the extreme end; it is better to leave as much of this portion unsoldered as can be soldered at the same time that the teeth are joined to the plate. It can be bent closer to the teeth and made to form a neater union with the backing after the case is invested and prepared for making the backings than at any other time.

After the rim is soldered and the plate cleansed with acid, place it on the cast to see that it fits as accurately as it did before—it is seldom that there is any material change if the work has been carefully done—then proceed to adjust the rim and finish it as far as is desirable to do before the case is invested.

Usually, during soldering there are slight changes in the position of the rim that need correction; at some points, too, the solder may have encroached upon the space needed for the teeth, in which case it must either be removed with the graver or the ends of the gums must be ground to accommodate it. The teeth, firmly held together by the plaster guides, are readily adjusted to the rim. It is desirable at this stage to make the free edge of the rim fit so closely that it can be burnished into absolute contact after the teeth are soldered; if made to fit too closely at this time, so as to bind upon the gums, there is danger of the teeth breaking during soldering. Any point that does not fit closely enough may be bent closer, either with the pliers or with the small bench hammer, the plate during the process being firmly held upon the cast, so that it may not be bent. The next step is to reduce the width of the rim at any points where it may be too wide: where it is not wide enough the width may be slightly increased by forging it out; but as this is difficult and uncertain, it is far better to make it too wide, especially as it is apt to move away from the teeth during soldering, and when bent back to its position will be a trifle narrower than it was before. As it is quite difficult to get a smooth, even edge to a rim after the teeth are soldered to the plate, the rim edge should be finished before the soldering, using for the purpose first the dead-smooth file, and afterward very fine sand- or emery-paper. Do not bevel the edge too much; it should be rounded rather than bevelled from the labial side, and left thick: it will be somewhat further reduced when it is burnished close to the teeth in finally finishing the case, and if made too thin is apt to tear and break during that operation.

The next step is to readjust and secure the teeth to the plate for investment. Naturally, we would think that this could be accomplished by simply heating the plate so that it would soften the cement, placing it upon the cast, and then pressing the guides in which the teeth are imbedded firmly in place.. If the rim has been swaged and riveted to the plate before the teeth were removed, this will often give accurate results; in other cases, however, it is very uncertain, and cannot be relied upon in any case. There seems to be a tendency in the rim to creep bodily toward the alveolar ridge during soldering, so that when the teeth are placed in it after it is soldered they are a trifle too long—not enough, perhaps, to seriously affect the articulation, but enough to prevent their fitting solidly to the plate. And, again, the surface of

the cement is left rough when the plate is removed ; little particles of sand or plaster or cement may keep the guide from coming into actual contact with the plate, or a slight change in the form of the plate, etc. may prevent the guides fitting exactly as they originally did. Ordinarily, it is very difficult to detect this error; to ensure accuracy the following method is recommended : Before removing the guides from the cast make a slight cone-shaped depression upon the guide, and another immediately below it upon the cast at about the median line; into these adjust the points of a pair of dividers, and accurately measure and note or mark their distance apart upon some portion of the cast, so that the dividers can be again set in the same position : by laying them aside where they will not be disturbed the mark upon the cast may be dispensed with. It is only necessary to again apply the dividers to these points to determine whether the guide is in its original position or not. It is frequently necessary to remove the cement and to cut the plaster away from the guide, so as to entirely free the plate (not disturbing, however, that portion which rests upon the back part of the cast), before the guide will fit in its original position. Occasionally it is necessary to grind the ends of the gums; this should be done very carefully, and not until it is found to be absolutely necessary : usually a little taken from the inside of the gums at their extreme ends will be sufficient. The anterior teeth require this more frequently than the posterior. It is seldom necessary to really shorten the gums. Whenever possible this grinding should be done without removing the teeth from the guide. If the teeth are kept together and are not removed from the guide, we may depend upon accurately replacing them; if they are removed, it is very difficult to replace them without some slight changes in their position.

In preparing the case for investing some prefer to remove the teeth, and, after removing its outer portion, use the guide as an articulating model, replacing the teeth, a few at a time, in the following manner: Place the plate upon the cast, and after fitting the teeth into the rim and the imprint of the cutting edge on the guide, drop a little hot cement upon the gums where they enter the rim; when this has set remove the guide carefully so as not to disturb the teeth, and add cement inside to secure them firmly to the plate. This is repeated until all are in place. The accuracy of replacement should be further tested by the articulating model, and in difficult cases it may be better to readjust them in the mouth. With a little care the uncertainty of this method may be avoided by transferring them from the guide to the investment in the following manner: After the teeth are accurately fitted to the rim, so that the guide with the teeth imbedded in it will go on the cast in its original position, cement the guide firmly in place, and then add a coating of plaster and sand mixed in the same proportions as will be used in investing the case to cover the rim and the exposed ends of the teeth : this is to form a portion of the final investment. When this is hard remove the outer portion of the guides, that portion which covers the face of the teeth, and which was made so as to be removable; cut away also the remaining portion, so as to expose about one-third of the grinding surfaces of the bicuspids and molars and any portion of the

teeth and plate which will assist in holding them firmly in the investment, and at the same time will not seriously endanger their firm hold in the guide. Then add a fresh portion of investment, allowing it to cover all exposed portions of the teeth and to overlap the portion first added, wetting this with water so that the two will unite. When this is hard chip away the cement holding the guide to the cast and carefully remove the guide. If the cement uniting the teeth to the plate was not removed when adjusting the teeth to the rim, it may be necessary to warm the cast and guide so as to soften it, unless it was properly shaped and coated with oil or other preparation before the guide was made to facilitate its removal. It is desirable that the portions of investment already added should be quite thin—say, about one-fourth of an inch thick—and as it is necessarily frail, and has but a slight hold upon the teeth and the plate, the removal of the guide must be done very carefully.

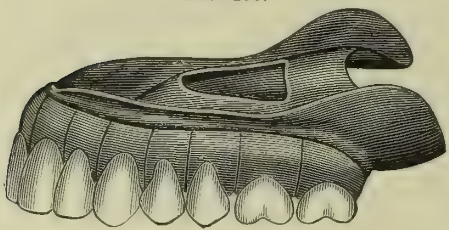
After the guide has been removed, as a precaution against accident add a little cement inside the case to hold the teeth to the plate; or if the cement is still there, unite it to the plate by heating it with a hot wax spatula. Some prefer to add soft wax to keep the investment from the inside of the teeth; I consider this unnecessary. Any workman should be able to invest a case neatly and without allowing the plaster to extend beyond the grinding or cutting surface of the teeth. Then remove the case from the cast, wet with water the investment already in place, and mix sufficient plaster and sand to complete the investment, using about five parts of sand to four of plaster, and adding a teaspoonful of pulverized asbestos. First fill the palatal surface of the plate, and then press it down gently with a slight rocking motion into a mass of the batter previously placed upon a piece of glass, until there is rather less than half an inch of the investment under the most dependent portion of the plate. Then take a piece of iron wire, bent to conform to the outer surface of the teeth, reaching a little beyond the molars of each side and with each end bent into a hook, and lay it in the plaster a little below the cutting edges of the teeth and in contact with the investment already in place. Wet the fingers with water and mould the investment over this, building it up to extend over the cutting edges of the teeth, so as to hold them securely in place. It should be made somewhat thicker than when the case is invested in the usual manner. Although the plaster added at various times seems to unite, the different portions are apt to separate when heated for soldering. The object of the iron wire imbedded in the investment is to hold the investment together in case it should crack while soldering. When the investment is hard proceed to make the backings and solder the case in the usual manner, cutting away the investment so as to reach the unsoldered ends of the rim, bending them around the molar teeth to meet the backings and be soldered to them.

While I have particularly described the mode of procedure in rimming full upper dentures, the changes necessary to adapt the various methods to lower or to partial cases are slight, and involve no special features requiring separate descriptions. Rims for silver cases should be made two or three numbers heavier than rims on gold cases.

Finishing the rim is necessarily deferred until after the teeth are soldered to the plate; if previously done the rim would be marred to some extent while burnishing it to the teeth.

In commencing to finish a rim the first step is to make its free edge fit closely to the gums of the teeth; this is accomplished by the use of the burnisher and the file—the burnisher to bend the edge, and the file to thin the edge when it is too thick for the burnisher to effect this (the bending of the edge), and afterward to remove the marks made by the burnisher and to give the rim a smooth and even surface. The finished rim is shown in Fig. 400.

Fig. 400.



Upper Denture Rimmed.

The operation of burnishing, when the object is to change the shape of a piece of mtal, is analogous to "metal-spinning," and is very different from burnishing to produce a hardened, polished surface. In the first the burnisher is used with considerable pressure; its motion is slow and deliberate, so as to effect the desired change before the metal has lost the softening effect of annealing and become hard and elastic. In the second the pressure is light and the motion rapid: an effort is made to condense and harden the surface, so that it will receive and retain a high polish.

When the gums are thin care is of course necessary to avoid accident. There is a little knack that practice alone can teach in manipulating the burnisher effectively.

After the edge is closely fitted to the gums of the teeth the special work of finishing the rim is complete: the further finishing and polishing require treatment similar to other parts of the case.

Constructing and Attaching Spiral Springs.

The introduction of plaster for taking impressions produced a marked change in the methods employed to retain artificial dentures in position. It not only enabled the operator to obtain a far more reliable cast of the surfaces to which the plates were to be fitted, but also directed his attention to the advantages a perfectly-fitting plate possessed. This has gradually led to the general adoption, for retaining dental plates in position, of the atmospheric-pressure principle, by which the use of spiral springs, formerly considered essential to the successful use of a full upper and lower denture, has been almost entirely superseded. Occasionally, however, a case may be met with in which they are required: it is desirable, therefore, in a work like this, to briefly describe their construction and use.

Spiral springs were formerly made of silver, an alloy of palladium or iridium and silver, and various alloys of gold to which a portion of platinum was usually added. Silver is not desirable for this purpose: the silver alloys mentioned make an excellent spring, but are difficult to work

and are otherwise objectionable in the laboratory. Practically, gold alloyed with platinum answers every requirement; if reduced to a low carat for use upon silver or other inexpensive dentures, the difference in cost between a pair of springs made of it and of silver or a silver alloy is but trifling, while the usefulness and durability of the gold are far greater.

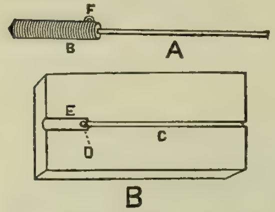
Where spiral springs can be purchased ready for use it is seldom desirable to attempt to make them. In selecting a pair of springs endeavor to get them as near the same strength or stiffness as possible, and see that they form a regular curve and do not bend more at one point than at another when their two ends are bent together, as they will be in the mouth, and also that when the pressure is released they quickly spring back without any permanent change of form. There is considerable difference in the strength of spiral springs: this must also be considered, and a weak or strong spring selected as the case may require.

To make a pair of spiral springs prepare the alloy of the required carat, adding about the same proportion of platinum as would be used if the alloy was intended for clasps. Form the wire in the usual way: while drawing it down anneal quite frequently, and keep it well lubricated with wax, so as to make the wire as smooth and free from flaws as possible. Considerable experience and judgment are required to properly proportion the size and temper of the wire to produce a spring of a certain stiffness. Do not anneal the wire after it has been drawn to within four or five numbers of the desired size, as it is desirable that it be somewhat hard when finished; if it proves too soft it may be tempered by drawing it through the fingers a number of times. The wire may be from No. 24 to 30, according to the stiffness required in the spring. It is usual, before winding the spring, to polish the wire by drawing it between the folds of a piece of soft leather charged with rotten-stone, afterward finishing with polishing rouge; this should be done gently to avoid making the wire too hard. The spring is formed by winding the wire upon a mandril, the wire being so held as to lay the spirals close together. A steel knitting-needle about one-twentieth of an inch in diameter and eight or ten inches long makes an excellent mandril for this purpose. It is very important that the tension upon the wire should be uniform, and that the mandril should be continuously turned until the winding is complete; a weak point is usually produced in the spring if the tension upon the wire is relaxed or the motion of the mandril arrested during the process.

A block of hard wood, with a hole through it into which the mandril tightly fits, is perhaps the simplest device for winding a spring. The wood is secured in the vice or by other means with the hole in an horizontal position; the mandril is passed through the hole, and is allowed to project from the right-hand side of the block sufficiently far to be grasped by a small hand-vise, by which it is turned. The end of the wire is secured to the mandril, and the mandril steadily turned so as to wind the wire upon it, the wire at the same time being guided to the side of the block, the tension upon it forcing it between the block and the portion of the spring already wound upon the mandril, the mandril being drawn through the block as the winding proceeds: this causes the coils to

be laid evenly and closely together. This device, simple as it is, requires two to operate it efficiently—one to hold and guide the wire, and another to turn the mandril, at the same time holding it steady by grasping it near the block by the thumb and finger.

Fig. 401.



Apparatus for Making Spiral Springs: A, mandril; B, portion fitted to lathe; F, loop to which wire is fastened; B, block supporting mandril; C, groove in which mandril turns; D, hole through which wire passes; E, enlarged portion of groove to accommodate spring wound.

A more efficient device, designed to be used with the lathe, is shown in Fig. 401. The mandril, A, is attached to the lathe by its enlarged extremity, B. To support the mandril when in use a block of hard wood, B, two inches long by one inch wide and half an inch thick, is arranged as follows: Lengthwise of the block and centrally located upon its upper surface there is formed a groove, C, in depth twice the diameter of the mandril and of width sufficient for the mandril to fit it tightly. From the bottom of this groove and about half an inch from one end drill a hole, D, one-sixteenth of an inch in diameter through the thickness of the block, countersinking each end sufficiently to remove the square edge and round the entrance to the hole at each side of the block. With a small round graver increase the depth and width of the groove from the hole just made to the nearest end of the block, as seen at E. The object of this is that the mandril may be evenly supported by the groove in the block when the portion of its length occupying this part of the groove is covered by the wire wound upon it.

In using this device secure the mandril in the lathe: the small lathe used for grinding teeth will answer if a stronger one is not available, as the power required is but slight. Pass one end of the wire through the hole in the block and secure it to the loop, F, on the mandril; turn the mandril a few times, guiding the wire so that the coils will be far apart: the object of this is, first, to more firmly secure the wire to the mandril; secondly, to occupy the space upon the mandril corresponding to the space between the end of the block and the hole through which the wire passes, so that when the winding begins the wire will be drawn through straight, and not at an angle, as would otherwise be the case. This, a little practical experience will quickly prove, is of more importance than at first appears. We are now ready to begin winding the spring. Place the end of the block through which the wire passes next the lathe-head, the mandril lying in the groove opposite the centre of and in line with the axis of the lathe-spindle; the right hand should hold the block firmly, and the fingers of the left hand, protected with a glove or a piece of cloth, regulate the tension of the wire by making it bear hard against the side of the hole, D. To make a good spring the wire should be held firmly and with a greater strain than would be prudent with the unprotected fingers. Slowly turn the lathe, increasing the speed if the winding is proceeding satisfactorily, and keep the block firmly pressed toward the lathe-head, so as to lay the coils closely together; the wire forces the block forward on the mandril too rapidly unless resisted by a firm, steady pressure.

There are several points to be carefully guarded in winding a spring. It is all-important that the first few coils should be laid closely together; they are apt to determine the character of all that follow: it may be necessary before proceeding to force them together with a burnisher if they are disposed to separate. See that the wire is not liable to become entangled in the lathe or with near objects or to form "kinks," as it is very apt to do. By attaching to the free end of the wire a weight of a few ounces this annoyance may be avoided. There is a constant tendency in the coils to ride over those already formed; this must be checked by sufficient tension. If the spring is a long one or if the fingers are insufficiently guarded, the friction of the wire passing over them becomes quite painful, naturally causing the tension to be relaxed and spoiling the spring. The end of the wire, if the wire is completely used up, becomes a source of danger as it passes through the block. It may coil around a carelessly-disposed finger or may be bent into a hook; in either case it is liable to do serious injury. This will suggest that if a weight is attached to it it should be secured by tying with a piece of thread that will either slip off or break—never by making a hook or loop in the wire.

Before describing the method by which spiral springs are attached and adjusted to the denture, there are several points affecting their usefulness and the comfort of the wearer which will be first considered.

The springs are arranged one on each side of the denture, one end of each spring being attached to the upper plate and the other end to the lower plate by swivelled joints. Their length is so adjusted that when the mouth is widely opened they are but slightly curved; when the mouth is closed the points of attachment approximate, causing the springs to be bent into a curve. Their effectiveness arises from the tendency of the curved springs to straighten, thus acting upon the points of attachment and pressing each plate upon the alveolus. This pressure is constant whether the mouth is opened or closed, and tends equally to retain in place the upper and lower plate. If properly arranged they do not materially interfere with the movements of the jaw, and, although inconvenient at first, patients soon become accustomed to their presence. They are, however, very liable to accident; they make the denture difficult to handle in the necessary daily cleansing; they retain the secretions, etc. offensively, and from these causes not unfrequently are a source of much annoyance.

In attaching and adjusting them the following points are to be considered: First, to avoid irritating the cheek they must lie closely to the teeth at all times, and not be liable to move from this position during the various movements of the lower jaw. Second, when the mouth is closed the springs should form a regular curve, approaching somewhat a circle rather than an oval form, the springs bending evenly throughout their length, and not sharply at any one point. This last may be due to a defect in winding the spring: stopping the lathe or relaxing the strain upon the wire for a moment during the process will frequently cause a defect of this kind. If the spring takes too sharp a curve, it may be due to the spring being too long or the points of attachment being too close together vertically, or to the manner in which the ends of the spring are attached to the swivelled joints, as will presently be

described. Third, they must not press upon the tissues of either jaw. This may be caused by the springs being too long, but is more frequently due to their attachment at the swivelled joint. Fourth, when the mouth is closed after being widely opened, there should be no possibility of the springs curving forward instead of backward. This is readily arranged for in the more desirable methods of attaching them to the swivelled joints. Fifth, the attachment at the swivelled joints should not only permit of the adjustments here noted being readily made and maintained, but also permit of the springs being easily removed to admit of repairs to the denture or to the springs, and as readily replaced without materially disarranging their adjustment. Sixth, they should work freely and smoothly at the swivelled joints, and all parts concerned in the attachment admit of ready replacment and repair.

The points of attachment are chosen, as a rule, first, for the upper denture, as nearly as possible on the line of equipoise, which is usually somewhere between the centres of the second bicuspid and of the first molar; secondly, for the lower denture, directly under the upper. Generally, unless the articulation is very long, the points of attachment are placed as far apart vertically as the plates will permit. Occasionally it is desirable to vary these positions to counteract some special tendency to displacement—more frequently, perhaps, to counteract a tendency to forward displacement—by placing the points of attachment slightly farther back on the lower denture.

The simplest method of attaching spiral springs is to place in proper position upon either side of the upper and lower dentures a button or stud made by soldering to the extreme end of a piece of round wire, about No. 22, a disk about one-eighth of an inch in diameter, a similar disk being then soldered about one-thirty-second of an inch inside of this, care being taken that no solder flows into the space between them. This button (shown at A, Fig. 402) is attached by passing the wire upon which it is made through a hole drilled through the tooth. Teeth are made to admit of this, the hole being formed during the process of manufacture, or it may be passed between the teeth, a narrow groove to accommodate it being made in two adjoining teeth by the sharp edge of a corundum stone. In either case the end passing through is soldered to the backing at the time the teeth are soldered. In some cases it may be soldered directly to the plate near the edge, just above the gums of the teeth. In all cases the inner disk is set in by grinding a countersink for it, so that its outer face is just level with the surface of the teeth. To these buttons the springs are attached by unwinding from each end a few turns of the wire of which they are made, and after annealing carefully coiling it between the two disks so as to form the swivelled joint. I do not consider this a desirable method when permanency is desired; neither does it admit of adjusting the springs with any degree of accuracy. Occasionally, however, as they are by this method readily and quickly adjusted, it may be used to advantage where the springs are desired for temporary use or to hold the plates in position while taking the articulation in difficult cases.

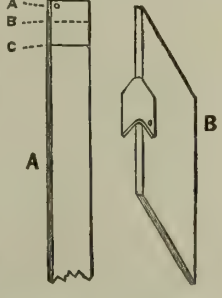
Fig. 402.

Button and Hook for attaching spiral springs.

An improvement upon this, using the buttons previously described, consists in securing the springs to them by means of hooks or end-pieces (shown at B, Fig. 402) constructed as follows: Take a piece of wire, preferably of gold, a trifle larger than will pass into the spring; form one end into a ring or hook that will snugly fit the stem of the button, and flatten it either with the file or hammer until it will fit between the two disks of the button: the ring is left sufficiently open to readily slip in place. This is then cut off, leaving a stem about three-eighths of an inch long to pass into the spring. Four of these are required, and each should be fitted to the button upon which it is intended to work. Those for the lower denture may be made a trifle longer. The ends intended to pass into the springs are carefully filed square, and are sufficiently reduced in size to admit of their being screwed into the springs. If this is neatly done, and the sides are made parallel and the corners sharp, the hard wire of the spring will make a thread upon it that will hold quite securely. Before adjusting the springs in place see that they, with the hooks or end-pieces in place, are of equal length. In some cases there may be a marked and unavoidable difference in the vertical distance between the buttons of either side; this is always objectionable, and wherever possible should be avoided when fitting them in place. When it exists, unless the difference is very great, it is seldom desirable to make any difference in the length of the springs. The springs are now placed in position. With a pair of narrow-beaked pliers carefully close the hooks so they cannot slip from the buttons. The hooks, fitting the buttons snugly, give the springs a greater degree of steadiness, while the portion passing into the springs facilitates very much the adjustment I will presently consider.

A better method, and one I have used exclusively, involves more labor, but is far more practical and useful. In this the buttons are replaced by "boxes" constructed as follows: Take a strip of plate, No. 25 (I prefer 18-carat gold in all cases; the amount used is so small that the additional expense is too trifling to be considered: it is harder, more elastic, and resists much better the solvent action of the secretions than silver, while platinum is too soft for this purpose), from one-eighth to three-sixteenths of an inch wide, and punch a hole at the point A, Fig. 403. File off the burr left by the punch, and with a pair of pliers bend the end at the dotted line B to a little more than a right angle. Cut this off at the line C, so that both ends will be of equal length. Repeat this, but bending in an opposite direction, so as to form a box for the opposite side. Four of these are required; those for the upper denture may be a trifle smaller than for the lower. These are now carefully annealed before further bending, so as to preserve the texture of the metal. Then select a flat piece of hard brass, as thick as the intended distance between the sides of the box (say No. 20); one edge of this should be straight and slightly rounded; it is to be used as a "former" upon which the boxes are

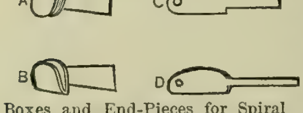
FIG. 403.



Method of making Boxes for Spiral Springs.

shaped. Place the partly-formed box over it, as shown at B, Fig. 403, and after first bending it over the former with the pliers upon the bench-anvil, with a small hammer close the sides to the brass; then with light blows of the hammer neatly round the bend. When this is done place the boxes upon a flat surface with the holes uppermost, and proceed to adjust to them the pins upon which the springs are to work. These pins are made of gold alloyed with platinum in the same proportion as would be used for clasps, and are fitted in the following manner: Take a piece of wire of sufficient diameter to tightly fit the holes; file the end square, and force it into one of the holes until it touches the opposite side of the box; without removing it cut off with a pair of cutting-pliers the portion in the box, and proceed in like manner until all are fitted. Then solder these in position, being careful that no solder flows into the box. When this is done, with a knife-blade separate the sides of the box, so that the free end of the pin does not quite touch: the object of this is to avoid the possibility of its being also soldered during subsequent operations. In a few cases these boxes may be soldered directly to the plate above the gum edges of the teeth. Where this is done care is required to prevent the solder from flowing so as to stiffen the outer side of the box; it is very important that this side should be free, so that it may be bent in or out to remove or replace the spring. Generally, however, the boxes are held in position by flat strips of plate passing between the teeth and soldered to the backings. To adjust these, place the box in the desired position, the end near which the pin is soldered toward the median line, the bend toward the edge of the plate, and the side to which the pin is soldered next the teeth: note or mark the most convenient position for the piece. It is best to have it as near the centre of the box as possible. At the same time observe whether it should slant up or down to bring the lingual end in the best position for soldering. If the alveolar ridge is flat, the piece will be vertically on the same plane as the box: in other cases, to bring the box as near to the edge of the plate as desired it may require setting at an angle or shaping to fit over the convexity of the ridge. Horizontally, they should be in all cases at a right angle to the box. Usually, they are adjusted to the box by the eye, the piece being held in place with hard wax and invested in plaster and sand for soldering. With a little care the investing may be dispensed with, the parts being secured in place upon the soldering support with iron pins. Solder them strongly, but avoid an excess of solder. After they are soldered file them to the shape shown in Fig. 404, A representing the upper box, and B the lower. They are then ready for fitting to the teeth. This is done just before the case is invested; it should be done neatly, and is a somewhat tedious task. To avoid undue prominence they should be set into the gums of the teeth by grinding a place for them with a very small corundum wheel, so that the inner surface of the box to which the pin is soldered is even with or slightly below the surface of the gums: they should stand vertically. In setting the upper ones especially there is a tend-

FIG. 404.



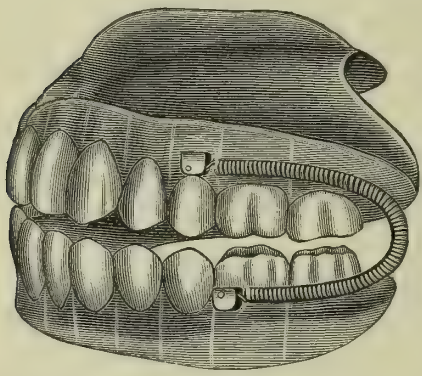
Boxes and End-Pieces for Spiral Springs.

ency, owing to the convexity of the gums, to allow them to lean out. This is a serious defect, and interferes materially with their usefulness. It is best in fitting them to first grind the groove through which the supporting piece passes, removing all from one tooth or equally from each adjoining tooth, as may be necessary to bring the box to its proper position. When satisfactory secure them in place with hard wax and invest the case as usual. Extra care is needed when removing the cement preparatory to making the backings to avoid displacing the boxes. The backings and connecting pieces are fitted to the supporting pieces of the boxes, and united to them when soldering the case, thus securing them firmly in position. When plain teeth are used the pieces pass between the teeth, little or no fitting being required.

The end-pieces of the springs are made of plate about No. 22 standard gauge. Those for the upper denture should be about as wide as the outside diameter of the springs, as shown at C, Fig. 404, the hole to fit over the pin in the box being made in the centre of its width and near the end. Those for the lower denture should be considerably wider (D, Fig. 404), the hole for the pin being made near the upper edge. After the holes are made they are separately fitted to the box in which they are intended to work. The end to be attached to the spring is then reduced by filing, making the sides parallel and the corners sharp, so that they may be screwed into the springs, passing into them about three-eighths of an inch, the other end being left sufficiently long to allow the spring to well clear the box. After the end-pieces are firmly screwed into the springs, see first that the end-pieces of each spring are on the same plane; that is, when the upper end-piece is in place in the box the lower one should pass into place in the lower box without twisting the spring. This is an important point, and if neglected would not only interfere with their adjustment, but also cause the pins to be worn unevenly. Secondly, see that the springs, including the end-pieces, are exactly the same length, measuring from the pinholes. Then with a pair of pliers slightly compress the last spiral of each end of the springs, and file and bend the end of the wire so that it will lie close to the end-piece, otherwise it may be bent out and prove a source of irritation. Place the springs in place, and without closing the boxes proceed to roughly adjust them. It is probable that the lower end-piece, striking the bottom of the box, will not allow the spring to go down as far as will be desired in the final adjustment: it is for this purpose that the hole is made in the upper edge, for the end-piece can at any time be readily depressed; but if at first it is placed so low as to allow the spring to press into the tissues of the cheek and gum, the maladjustment cannot be corrected without making a new end-piece. Remove sufficient from the lower edge of the end-piece to allow the spring to go down as low as desired. When the springs are so far adjusted that they work freely remove them, and finish and polish the end-pieces. When the denture is entirely finished and ready for the mouth the springs are attached and the final adjustments made. After placing the springs in position close the boxes with light taps of a hammer or by carefully compressing them with the pliers, so that the end-pieces cannot slip off the pins. The flat end-pieces working in the boxes made as described hold the springs far more steadily than either of the

methods previously referred too, and on this account permit of more accurate adjustment. Proceed to the final adjustment in the following order: First, slightly bend the portion of the end-pieces entering the springs toward the median line. The object of this is to so incline the end-pieces that the springs cannot curve forward in case the mouth is closed suddenly after being widely opened. Next see that when the denture is closed the springs form a full well-rounded curve; if the curve is too sharp, it may be corrected by bending the end-pieces: do this cautiously, as it is at times difficult to determine at once in which direction the bend should be made. By bending the end-pieces laterally the springs are made to work as closely to the teeth as possible without rubbing upon them. It is important that they should work smoothly and freely in all positions the denture may assume in the mouth; therefore in adjusting them imitate as nearly as may be the natural movements of the jaws. The comfort and usefulness of springs and their durability depend very much upon the accuracy of their adjustment. In case of repairs being needed to the springs or to either denture the springs are readily removed by inserting a knife-blade in the box and springing it apart, so that the end-pieces can be slipped from the pin; they may be in like manner replaced after the repairs are made without materially disarranging their adjustment. This is an advantage not to be overlooked. A full denture with springs arranged as described is shown in Fig. 405.

Fig. 405.



Full Denture with Spiral Springs in position.

Repairing Gold or Silver Dentures.

It is always best, before repairing a case, to examine it in the mouth and note the accuracy with which it fits. This precaution may save an annoying dispute with the patient after the repairs have been made. Patients do not, as a rule, appreciate the fact that there is a change constantly taking place in the form and shape of the surfaces upon which the plates rest; they do not notice from day to day this gradual change, and in many cases continue to wear with satisfaction a denture they have become accustomed to long after, on account of absorption of the aveolar border, it has ceased to fit. In such cases, if the plate is kept out of the mouth a few days while the repairs are being made, this and the thorough cleansing the plate receives during the process of repair, causes the change to be at once noticed. If attention has not been previously called to it, even honestly-disposed patients are apt to attribute the change to some injury the plate has received during the process of repair. Not only carefully examine the denture in the mouth,

but also carefully note its condition, and direct attention to any injury it has received necessitating repairs other than those the patient has desired. There may be injuries of but little importance at the time, yet liable to become serious during the process of repair; for instance, a tooth may be fractured in such a way that its strength is but slightly impaired; during the process of repair it may be still further injured and require renewal. It is always a satisfaction to all concerned if, before any responsibility is assumed, attention is called to these matters and the patient is fully informed of the condition of the denture and the probable risk attending its repair.

Adding to a full upper or lower denture or to a partial denture a tooth in place of one that has been broken or otherwise displaced is, when the adjoining teeth are also artificial, a simple matter. It is well in these cases to inquire into the cause of the mishap. It may be that the tooth or teeth have been the subjects of undue strain: if this is the case, a recurrence of the accident should, if at all possible, be guarded against when making the repairs. The tooth may be made slightly shorter or be set out a trifle, or the backing may be brought quite to the cutting edge, so as to take a share of the strain, and thus relieve the tooth, or a little removed from the opposing teeth may be, in some cases, a more desirable remedy. As the natural teeth wear from constant use, the manner in which the teeth close becomes changed, and the strain upon the teeth is unequally distributed. This is a frequent and constant cause of teeth being broken from plates. This naturally suggests the advisability of always taking an articulation before repairing these cases—simply placing a little wax, not too soft, in the space from which the tooth has been displaced, and requesting the patient to tightly close the teeth, a plaster model being made from this impression in the usual manner.

In some cases considerable time may be saved, and the risk always attending soldering teeth that have been worn for some time avoided, by riveting the new tooth to the old backing. To do this successfully the new tooth must be, in all essential points, a duplicate of the old one and have long pins. After the tooth is sufficiently fitted to allow the pins to rest solidly against the backing, and to determine accurately the position it will occupy, proceed in the following manner to mark and drill the rivet holes in the backing: First, coat very thinly the surface of the backing against which the tooth will rest with wax, and then carefully press the tooth against it, holding it as nearly as possible in the position it is to occupy. On removing the tooth the imprint of the pins will be plainly marked in the wax Then with a sharp drill corresponding in size to the pins drill the rivet holes at the points indicated; never attempt to make them with the punch: not only is there difficulty with that tool in getting them in the exact position, but there is also a risk of the backing being bent or cracked by the force applied. Not infrequently, especially if the case is rimmed, on account of the pins resting against the backing and preventing the tooth from going into place, it is difficult to determine its exact position until after the rivet holes are made. In these cases in drilling the holes we may sometimes allow for the change that will take place in the position of the tooth when it fits

closely to the backing; in other cases it may be necessary to enlarge the holes in the direction required to permit the tooth to assume its proper position. This is best done with a saw sufficiently narrow to pass through the rivet hole: one end of the saw is released from the frame, passed through the hole, readjusted to the frame, and the hole carefully enlarged in the direction required. A slight change in the position of the tooth may be made by bending its pins. Enlarging the rivet holes should be avoided whenever possible: it always weakens the attachment of the tooth to the backing, for, although it may be possible to make the rivet head large enough to well cover the hole, so that there will be no risk of its slipping through, there is always a risk of the tooth working loose when the pins do not fit the rivet holes accurately. The weak point of riveting, especially when the strain to be resisted is in almost direct line with the length of the pin, as is the case with the upper front teeth, is the stretching of the pins; this allows a slight motion of the tooth, and weakens its attachment, not only by reducing the calibre of the pin, but also by the wear of the pin this motion of the tooth permits. Where a tooth is soldered to a backing the pins are not only held more firmly, but the solder, taking hold of them quite close to the porcelain, leaves a much smaller portion of its length liable to stretch than when a tooth is riveted.

After the tooth is accurately fitted see that its pins pass through the rivet holes easily and without strain; see also that the rivet holes are neither too close together nor too far apart; in either case the risk of fracturing the tooth in riveting is very great. This being done, countersink the rivet holes from the lingual side of the backing, making the countersink cone-shaped at an angle of about 60° to 90°; if made too obtuse, either the rivet head or the portion of the backing against which the rivet head rests will be unduly weakened; if the angle is too acute, there is risk of the head pulling through. The objects of this countersink are threefold: First, to give the head of the rivet such a shape that the tooth will be held firmly to the backing; second, to allow sufficient substance in the rivet head for strength without undue projection beyond the surface of the backing; and thirdly, to reduce the length of that portion of the pin liable to stretch—namely, that portion between the porcelain of the tooth and the inner portion of the rivet head.

When all is ready for riveting rest the face of the tooth upon a block of lead (a counter-die answers the purpose nicely), so that the portion of the tooth immediately under the pins will be solidly supported, interposing a single thickness of thin paper to prevent the lead marking the tooth, and direct light taps with the blade of a small hammer around the outer edge of the pins, so as to thicken them and make them fill the countersink. Avoid striking directly upon the top of the pins until the riveting is nearly complete. It is a great mistake in riveting to direct the blows directly upon the top of the rivet; when so done there is not only danger of the rivet bending, but if this is avoided the head is forged out thin with weak edges, and covers rather than fills the countersink. Such a rivet never holds firmly, and when the rivet is composed of so soft a metal as platinum is utterly worthless.

The blows should be light, not only to avoid undue strain upon the tooth, but also by their repetition to harden the platinum. In cases where the pins of the teeth are not readily accessible it is necessary to use a straight punch to reach them, resting the face of the punch upon the pin while an assistant strikes the other end with a hammer. The punch used for punching the rivet holes in backings has been recommended as a useful tool for riveting teeth. It is used by placing the broad perforated jaw upon the face of the tooth, a thickness of leather, wood, copper etc. being interposed to prevent injury to the tooth, and the punch being made to bear upon the ends of the pins. Upon applying pressure the pin is compressed: a rivet head is quickly formed, generally by bending the end of the pin over. The countersink is very seldom if ever solidly filled, as it is when a hammer is used; the result is deceptive and unreliable.

In riveting a tooth direct a few blows to each pin alternately, so as to rivet them evenly; if this is neglected, and one pin is first riveted thoroughly tight, the tooth will generally be fractured in the attempt to rivet the other. Care is needed to prevent the tooth from changing its position during riveting; the tendency to do so is overcome by judiciously directing the blows. It is impossible to direct how this is done; it is a matter that can be learned only by practice.

Properly done under favorable conditions, riveting makes a firm and reliable attachment, but not equal in these respects to soldering. In many cases when from any cause it is not desirable to subject the plate and teeth to the heat necessary for soldering, it may be resorted to: for instance, a crack may be repaired by riveting a piece of plate over it, or an addition to sustain either a clasp or teeth may be firmly united to an old denture by this method. In adding to a case by riveting, if two or more rivets can be soldered to the added piece the operation will be far more readily and securely done. Platinum is usually preferred for rivets on account of its softness when annealed and its property of hardening under the hammer.

Simple as the operation may seem, there is an art in riveting that an ambitious workman will never regret acquiring. Used skilfully in many cases presented for repairs, time may be saved and risk avoided by its use.

In adding to and repairing artificial dentures the same care used to secure correct models for new work should be observed; indeed, it seems even more important when we consider that carelessness in making a slight repair may render useless an expensive denture. There is no real saving of time in taking risks that the few moments required to secure a plaster impression would avoid. In all cases where a model is required (unless the case is to be refitted) the impression should be taken with the denture in position in the mouth. The practice of taking a wax impression of the mouth, and attempting to carve the model made from it so that the plate will fit, is slovenly and unworkmanlike: it is never accurate, and frequently causes a great deal of extra labor before the case is finally dismissed. In all cases where teeth or clasps are to be added, or a tooth to be replaced adjoining a natural tooth or resting upon the gum or fitting over a root, or where the plate

is to be extended, place the plate in position in the mouth, and with a spatula, aided by a lock of cotton held in the tweezers, build plaster, mixed moderately stiff, over those portions of the gums and teeth of which a model is required, extending it somewhat beyond the parts immediately concerned and over the plate to such an extent that the plate and the impression can be accurately adjusted to each other after their removal from the mouth. Done in this manner, the operation is neater, easier for both patient and operator, and far more accurate than if the impression were taken in the usual way. The denture to be repaired forms part of the impression: there is therefore no doubt as to its position upon the model made from it.

In many cases where the plate has been broken—as, for instance, where a clasp or a portion of the plate supporting one or more teeth has been broken off, or where a partial lower plate supporting the posterior teeth has broken at some point where it passes around the anterior teeth, etc.; in fact, in all cases where actual separation of the parts has taken place, and where there is the slightest doubt about their accurate readjustment—it is far better to place them in position in the mouth, build plaster over and around them in the manner before described, so as to hold them securely in position, and after removal from the mouth place them in the investment for soldering at once. When this is done there is an absolute certainty of its fitting after the repair has been made as well as it did before it was broken.

In simple cases of adding new plate surface where only one or two teeth are involved, it is seldom necessary to make a die and swage the added plate. It can usually be bent to fit with sufficient accuracy with the pliers, or a piece of very thin platinum may be burnished to fit the model accurately, and sufficient plate, either gold or silver, be added at the time it is soldered to give the required stiffness. When a die is required, first trim the edge to which the addition is to be joined, file it to a feather edge, and make it fit closely to the model; secure the denture to the model while making the die, the die produced being a fac-simile of the model with the denture in position. By these means the new piece may be swaged to fit in place accurately.

In some cases it is better to solder the addition to the denture before fitting the teeth; in others, the teeth and plate can be soldered at the same time. It is desirable, when possible, to avoid the second soldering.

The additional risk in soldering teeth that have been worn is supposed to be due to the presence in them of fatty matter and moisture absorbed from the mouth; which substances, when heat is applied, vaporize and expand, evolving steam or gases more rapidly than they can escape. Baking or thoroughly drying the case in a sand-bath, so as to gradually drive off the gases, has been recommended. I do not think this necessary in ordinary cases. If the case is invested in plaster and sand in the proportion and in the manner recommended for new work, and the mass is slowly heated in a furnace or over a gas-flame to nearly the heat required for soldering, the risk of fracturing the teeth from the above-mentioned cause is very slight. In soldering repairing cases, always make them sufficiently hot to thoroughly burn off the discoloration

which usually appears upon the surfaces of the teeth when the heat is first applied, this being no doubt caused by the fatty matter which they have absorbed being driven to the surface and there carbonized. If this is neglected it may be necessary to reinvest the case and reheat it, for burning it off at a high temperature I have found to be the only method to effectually remove these stains.

Cases are occasionally met with where all danger to the teeth may be avoided by thickly coating them and the plate in their immediate neighborhood with plaster and soldering immediately before it has set. The evaporation of moisture from the wet plaster keeps the teeth cool. I have frequently by these means flowed gold solder within half an inch of porcelain teeth without their becoming heated to a dangerous degree. When this is attempted, however, the parts to be soldered should be so arranged that the blowpipe flame will readily reach them, as it is essential that the operation of soldering should be quickly done. In these cases always cool the plate immediately after the soldering has been completed to avoid danger from the heat being conducted to the teeth. I have also in difficult cases, where the operation of soldering was necessarily prolonged, packed wet sponge around those portions of the denture I desired to protect.

Cases where the plate is cracked frequently come to us with the crack widely open. As a rule, it is better to leave it so. The crack is often caused by a change in the form of the mouth subjecting that portion of the plate to undue strain, and the plate usually therefore fits better as it comes from the patient's mouth. Never depend upon solder alone in repairing a crack; in all cases lay a piece of plate over it.

ARTIFICIAL DENTURES OF ENAMELLED PLATINUM (CONTINUOUS-GUM WORK).

By D. D. SMITH, M. D., D.D.S.

Artificial dentures constructed after the style known as "continuous-gum work" surpass in some important particulars all other substitutes for natural teeth which have yet come to the notice of the dental profession. The basis of these dentures is a plate of platinum, to which the teeth are first soldered, and then united to each other and to the plate by a siliceous compound—porcelain cement—which when fused forms an artificial continuous gum between and about the teeth and over the plate, without joint or seam, giving to the completed case its appropriate if not euphonious name, continuous-gum work. Experiments made by M. Delabarre of Paris about 1820 in the direction of this form of denture have associated his name with its conception and early history. The material or porcelain cement with which he endeavored to unite the teeth to the plate is said to have been not unlike ordinary tooth-material. The high temperature required to fuse this compound caused the abandonment of experiments with it before any satisfactory results were attained.

So far as is now known, no further thought was given to the matter until about 1844, when Dr. John Allen of New York City, then of Cincinnati, Ohio, commenced a line of experiments which, extending over a period of seven years, resulted in the production of this most beautiful style of denture and embodied the main conceptions and features presented in the work as it is now constructed. If some minor details have since been added by others, to Dr. Allen belongs, without question, priority of practical construction and the perfecting of material for body and gum.

The advent of the continuous-gum work marked an advance in the æsthetics of prosthetic dentistry, with which Dr. Allen's efforts are as closely allied as they are with that of perfecting the mechanics of this denture. Until this time little or no thought had been given to the important matter of restoring with a denture other losses than those of the teeth alone. With the possibilities opened by the invention of this work are coupled the intelligent, untiring efforts of Dr. Allen to restore to the face and features all losses resulting from extraction of the natural teeth and absorption of alveolar and gum tissues, and the consequent distortion and apparent aging of the features. The practical demonstrations, together with some important writings, which he has

given to the profession of possibilities in this department of dental requirements have made the dental profession his debtor through all the future.

The continuous-gum work was first introduced under a patent, and, as it required not only a knowledge of furnace-work, but special instruction as well for its manufacture, its adoption by dentists was slow and its successful construction infrequent. Whatever favor it may have gained from the time of its introduction, 1851 to 1860, the time of the general adoption of vulcanite, it as quickly lost before its cheaper and more easily constructed rival. After the full introduction of vulcanite, interest in metal-work—gold, silver, or platinum—rapidly declined. Furnaces gave place to vulcanizers; blowpipes, apparatus for making dies, etc. were superseded by rubber files, scrapers, and sandpaper; metal plates were esteemed so unimportant that students were uninstructed in any of their forms, until a generation of students came upon the stage literally incapable of mounting a tooth on a gold or silver case, and without even having so much as seen a set of continuous-gum work. Even the dental colleges esteemed metal work of so little importance that no requirements in this direction were laid upon students, and for years little except vulcanite was made in college laboratories, as is abundantly witnessed by the sets deposited in their museums. The continuous-gum work has been depreciated and maligned by its enemies, and quite frequently very improperly constructed by its friends. An extract from a pamphlet published in 1884 shows what criticisms are still passed upon it:

"Continuous-gum work is still popular in dental colleges. It has never come into general use, for the reasons that the process is not easily acquired; the necessary outfit too expensive for a dentist with a small business; in entire sets there is a disagreeable clinking when in use; the rigidity of the plates prevents their being adjusted to fit the mouth when inflamed, so that the wearer must either bear the pain or go without them; the uncertainty when repairing; and, being more expensive than gold-work, its use is limited to the wealthy.

"It is impossible to unite porcelain with any metal without its cracking by shrinking.

"Every porcelain tooth, when examined with a magnifying-glass, presents a crack around the pin. The difficulty in repairing porcelain-gum work comes from enlarging these cracks by a second heat, as porcelain shrinks after each heat. Manufacturers bake teeth now with but one heat."

The author of these objections must be credited with some originality in framing them, although they indicate a lack of knowledge of the merits and demerits of continuous-gum work. There is but a single valid objection in this whole list—"disagreeable clinking when in use"—and that belongs to every form of mineral-teeth dentures. What, then, are the features of continuous-gum dentures which recommend them to the profession and to patients, and what are the objections which attach to them?

Recommendations.—First, adaptability. Pure platinum rolled into thin plates being the base of these dentures, they possess this most import-

ant requisite to a degree equal to any plate, vegetable or metallic, now known. In the estimation of the writer there is but a single class of mouths in which continuous-gum plates may not be fitted to be worn with comfort and satisfaction. These conditions are not numerous, but when they exist metallic plates are not indicated, neither will they be tolerated. The conditions alluded to are where a seam, amounting almost to a fissure, is found in the centre of the mouth, extending from the base of the alveolar ridge to the junction of the hard and soft palates, forming folds of mucous membrane which overlie a thick mass of easily-compressible adipose or muscular submucous tissue. These mouths, presenting no stable basis for attachment, are unsuited to any metallic plate, while vulcanite or celluloid may sometimes be tolerated. Secondly, the continuous-gum work possesses capabilities of perfect adaptation of teeth in size, shape, color, position, and pitch for the most perfect imitation of the natural gums and the restoration of the features to their normal expression. Thirdly, presenting pure platinum on one surface and fine porcelain upon the other, its cleanliness is unapproached by any other denture. Fourth, from the plate being a good conductor of both heat and electricity, and the porcelain being susceptible of perfect cleanliness, continuous-gum dentures are eminently non-irritating. A well-fitted plate may be worn for years without irritation or alterations. Fifth, its capabilities of repair are such as to leave nothing to be desired upon this point, for it may be repaired as certainly as any other form of denture, and when the repairing is properly done the denture is equal to new. Sixth, of its durability this only need be said : it cannot be worn out in a lifetime. The porcelain may be broken and the plate injured while out of the mouth, so that restoration may be impracticable, but with proper treatment continuous-gum work is practically imperishable.

Objections.—First, their weight. The weight of continuous-gum dentures is an objection to their use, but by no means as great as is frequently made to appear. The weight of a denture within reasonable limits is not appreciated if the plate is well adapted. *Any* metal plate that requires an effort to retain it seems heavy to the wearer. Scores of instances might be cited showing change from vulcanite or celluloid to continuous gum with no inconvenience to the patient, and without remark upon the increase in weight. Experience teaches that weight as an objection to continuous-gum dentures applies with greatest force when they are out of the mouth. Care is required in handling to prevent accident, and nearly all the breaking of teeth and scaling of material from the plates is due to falls occasioned by careless handling. A well-made set of continuous-gum work is seldom broken in the mouth. It has been said that one may wear a heavy set of teeth as one might wear a heavy boot, without being aware of the greater comfort to be found in light-weight teeth and boots. But the comparison is not a just one, for the continuous-gum plate, if properly adjusted, is held in place by the same force and with the same unconsciousness as is a lighter plate. Only when detached while in the mouth does the weight become apparent. Second, its solidity and the unpleasant mineral sound of the teeth in occlusion. These are real objections, but the latter is common

to all mineral-teeth dentures. Mineral teeth, on whatever base they may be mounted, have a sharp, harsh sound in occlusion, entirely distinct from that of natural teeth or artificial ones made of ivory. This mineral sound is not more unpleasant nor more easily distinguished in continuous-gum dentures than in those mounted on any of the vegetable or metallic plates.

After an experience of twenty years in making continuous-gum work, the objections named are all that the writer can admit against it. To urge *expense* attending its construction as an objection to it is like citing the cost of a diamond as an objection to its brilliancy. That it requires skill and a high order of talent to construct it artistically is admitted, but that this should be made an objection to its use is preposterous. Another objection sometimes made to it is that it is not adapted for partial sets. This is admitted, but the objection is without force in reference to full dentures. That gold plates are not as well adapted for entire sets as are continuous-gum or vulcanite bases is not an argument against gold plate for many partial sets, where it serves a better purpose than any plate of which we now have knowledge.

Continuous-gum dentures are not as satisfactory, nor do they meet the requirements as well, in lower cases as in upper. This is contrary to the generally received opinion that the weight of continuous-gum dentures is an advantage in lower sets to assist in holding them in position. Weight within proper limits is not a disadvantage to a plate for the upper jaw when it is so adjusted to the parts upon which it is designed to rest as to be sustained actually by atmospheric pressure. The same weight in a lower set does not appreciably assist in retaining it in position, but rather promotes irritation at points along the edges of the plate, and frequently induces a renewal of the process of absorption along the whole alveolar ridge. While this is an important objection, it is not the only one to continuous-gum work for lower sets. From the shape of lower plates they are more liable to accidents when out of the mouth, and they are far more easily broken even by use in the mouth than upper sets. There is little opportunity to make those changes which are so frequently demanded in lower sets without seriously marring the plate. There is not the frequent *demand* for continuous-gum work to meet the requirements of appearance in lower sets that exists in connection with upper ones; but where for any reason it is desirable to construct a continuous-gum denture for the lower jaw, it will be found much better to make the adaptation of the plate with vulcanite, after a process to be hereafter described.

Continuous-gum dentures are especially adapted for the upper jaw, and may be so constructed as to meet every requirement of adaptation, appearance, and position of the teeth and restoration of facial expression.

General Directions for Constructing Continuous-gum Dentures.

Impressions.—Whatever impression-material may be used or whatever methods adopted for securing an impression of the upper arch,

there is one test which always enables the operator to know the character of the result. If on raising the lip from the impression it is found firm and held forcibly in position by atmospheric pressure, it may be relied upon. If it is not firmly adherent, it should be discarded. From a good impression it is not difficult to make a perfect cast. For this purpose a plaster should be used which has proven by experiment not to change markedly in setting and drying. The cast being ready, decision should be reached whether the plate shall be made with or without a cavity. An atmospheric-pressure cavity in a plate is by no means a necessity for secure retention. Occasionally it is demanded, but in the ordinary arch-shaped mouth (Fig. 406) the plate is better if perfectly

Fig. 406.

Showing the Outline of an Ordinary Arch.

adapted to all its parts. In a mouth where the alveolar process is so absorbed that the arch is obliterated, diminishing the surface and affording no mechanical assistance in sustaining the plate; where long teeth are required and to be set outside the arch,—in all such cases a cavity-plate will give greater stability, and consequently greater satisfaction, than one without a cavity. Cavities in plates are frequently made too deep, and thus cause an increasing thickening of the mucous and submucous tissues, until the cavity in the plate is filled with a mass cartilaginous-like in character and a decided obstacle to the adhesion of the plate. The endeavor with all central cavities should be to so shape and place them that the parts of the mouth over and adjacent to the cavity will merely be placed upon the stretch, and not be permanently elongated and indurated. Sufficient surface of plate should always be left back of the cavity to make it *central.* By placing the cavity too near the posterior boundary the plate is generally made to drop a little from the ridge, causing a feeling of insecurity and rendering dislodgment easy. Cavities are best provided for by first marking boundaries for the plate and placing in position on the cast a piece of tin or lead plate of the desired shape and thickness. This will then be formed in the die, and the cavity be readily swaged in the plate. This is the only way a vacuum-chamber should be constructed for the work under consideration.

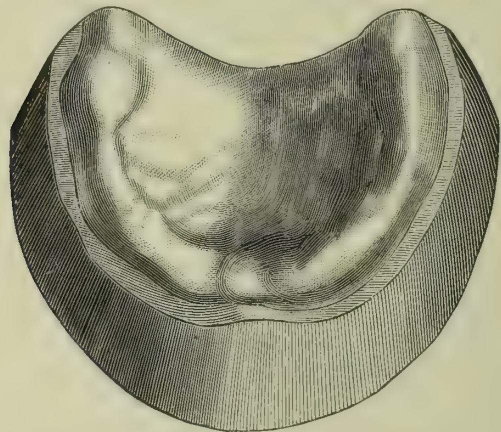
Preparations for marking the height of the plate and for turning a rim should also be made in the cast before varnishing. Experience and a close investigation of the mouth will alone determine the line to which the plate may extend external to the alveolar border. Great importance attaches to this matter, as if left too high irritation of the mouth will follow, and changing the completed case at this point seriously mars the appearance and often demands reheating. More important still is the mechanical steadying of the plate, secured by allowing

it to extend over the alveolar border throughout its entire extent as high as possible without irritation. Having marked this line, wax or plaster should be so built upon the cast that the rim will be formed and partly turned in the plate in swaging.

Fig. 407 shows the cast of an upper jaw ready for moulding for continuous-gum work.

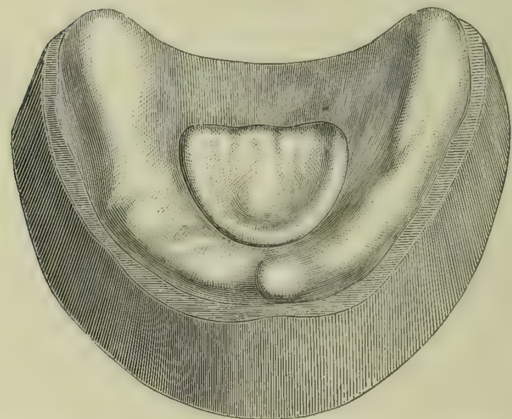
The process of moulding and making dies need not be here described,

Fig. 407.



Cast of the Upper Jaw, with ledge for turning the rim.

Fig. 408.



Cast of Upper Jaw, ready for moulding. The model for the vacuum-chamber is in position.

it being the same as for any metal plate. At least one die of zinc and counter of lead should be made; and if the cast is of medium size zinc will be found the most desirable for a finishing die. If the mouth is broad, having prominent and hard tuberosities, the shrinkage of the zinc die will cause the plate to bind over these prominences, and a metal having less contraction should be used in order to produce the

required adjustment. The Babbitt anti-friction metal or pure tin will be found satisfactory in such cases.

Having one good die of zinc with counters of lead, and one of tin if necessary, and counter of the same, the next step is the selection of the metal for the plate. Pure platinum is the metal generally conceded to be the best base for continuous-gum work. Palladium possesses the requisite infusibility, and is but little more than one-half the specific gravity of platinum, and, despite its elasticity, might perhaps be used for this purpose but that its scarcity puts it beyond reach. The alloy of platinum and iridium presents no advantages in weight, color, or strength over the pure platinum, and, as the latter is far more easily adapted to a die than the former, it is much to be preferred.

The thickness of the plate for an upper set should not in ordinary cases vary much from No. 29 United States gauge. In small mouths, where no unusual strength is required, No. 30 will answer as well. In larger mouths or where unusual support is desired No. 28, or even No. 27, may be used. It should be remembered that the weight is given to the case largely by the platinum plate and stays. Plates for lower sets, if to be made without vulcanite adjustment, should be No. 26 or 27.

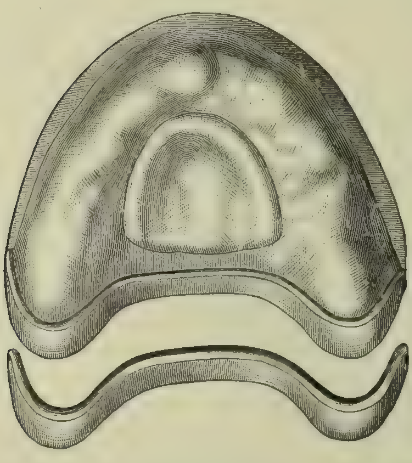
Having selected the thickness of plate, it should be cut to a carefully-fitted pattern, that there may be no unnecessary waste.

Pure platinum in thin plate when annealed is quite soft and easily contaminated with baser metals. For this reason it is desirable to interpose some medium to prevent contact as far as possible with the zinc or tin die. Fine wrapping-paper over the face of the die answers this purpose well. The annealed plate should be so placed upon the die as to reach all parts designed to be covered, and a coaxing rather than forcing process commenced in adapting it to the die. The soft platinum is quick to fold, and more ready to tear under force than to stretch. The distinguishing properties of platinum, as developed in working it into adaptation to a die, must be learned by experience before accidents in swaging in irregular cases can be wholly avoided. A tear in the plate can be remedied by soldering over it a small piece of thin platinum. When the plate is so adapted to the die with wood or horn mallets or tools as to require the use of the counter-die for further adjustment, a piece of thin muslin should be thrown over the plate to prevent contact with the lead counter. This should in no case be neglected, as it serves the double purpose of preventing contamination by the lead, the most injurious of the base metals, and of furnishing an easy means of removing the die with the plate upon it from the counter after swaging. The process of forcing the plate upon the die with the counter should be carefully conducted, and examination frequently made to correct any displacement or foldings of the plate. The final swaging should be sufficient to force the plate into all the inequalities of the die, and thus into adaptation to the mouth. Any points in the plate which the swaging fails to bring into perfect adaptation, as about the central cavity or deep undercuts in front of the ridge, may be adjusted with a hammer and properly-shaped bone or wood points.

The plate should now be trimmed to conform to the die as outlined in the cast, when it is ready for the additional piece of platinum which is to form the metallic boundary of the porcelain and the posterior portion of the plate as well. A piece of No. 19 platinum wire should now be soldered across the entire extent of the plate, three-sixteenths of an inch from the posterior boundary, and conforming to its irregularity. This wire on the outer portion of the alveolar ridge should be gently curved toward the front of the plate, as seen in Fig. 409. Next, a piece of plate, No. 27 or 28, should be selected, wide enough to cover the wire and all parts of the plate back of it, and swaged into thorough adaptation. Care is required in this operation to prevent tearing the plate over the tuberosities and just in front of the wire. The wire already soldered to the plate must in swaging become imbedded in the counter-die. It will be assisted in this, and the liability to accident lessened, by graving a gutter in the lead conforming to the imprint of the wire. When the new piece has been swaged into place all surplus extending in front of the wire is to be trimmed sharply and evenly away, when, after again swaging, it is ready to be soldered into place. For this purpose the contact surfaces are treated with borax and bound in place with wire clamps. Pure gold placed in front of the wire is fused under the blowpipe, and thus drawn through to the posterior portion of the plate, solidly uniting the wire and the added portion of plate, giving it the appearance presented in Fig. 409.

This device for forming a boundary for the material and for leaving a portion of the plate exposed meets a number of requirements in perfecting continuous-gum work: First, it obviates the abrupt thick boundary which is necessitated by the old method of turning the plate at this edge; it keeps the enamel at its thinnest portion a safe distance from the posterior boundary, and protects it by the added thickness of the plate; it adds greatly to the strength of the case without materially increasing its weight; and, more important still, it seems effectually to prevent changes in the plate when fusing the material; it provides a means of changing the palatal edge of the plate to increase or relieve pressure after the full enamelling of the case—a matter frequently of considerable importance.

Fig. 409.



Showing Piece of Plate to be soldered over and back of the wire, and the same in place on the plate.

Since devising this method of constructing plates the writer has practised it universally, and with uniform success in preventing the warping of plates. A plate constructed in this manner can be reswaged at any stage up to the time of arranging the teeth.

When carefully adjusted to the finishing die, it is ready for trial in the mouth—a test which should *always* be made prior to the arrangement of the wax. That a plate is perfect in its adjustment to the die, and even to a cast made from a good impression, is no guarantee that it will adhere in the mouth as well as it may be made to do. There are hard and soft places in mouths on which plates should rest with a pressure as nearly equally distributed as possible, of which impressions and casts give no indication. One great advantage over vulcanite the continuous-gum work has in common with all swaged plates is that we are able to adjust the plate accurately to the mouth before attaching the teeth. Too much emphasis can scarcely be laid upon the manner in which this part of the work is done, as different parts of the same mouth are unequally compressible. Upon it will depend the utility of the denture and no less the comfort and satisfaction with which it will be worn.

The first test in fitting a plate to the mouth is to ascertain if the patient can produce a vacuum under it. This accomplished, it should be tested with pressure on all parts of the ridge and from different directions. The best method of making such pressure is with the point of an excavator. If displaced by pressure at any one point, careful inspection should be made to ascertain the cause. In the great majority of cases it will be found to be from an unequal bearing of the plate, due to want of close adjustment, or to the yielding of some soft, movable tissue under some part of the plate. The impression may have been faultless in so far as we are able to obtain an impression of hard and soft tissues at one and the same time, and yet the plate may be very unequal in its bearings. The point now to be attained is to *make* the plate to bear with equal pressure on the unyielding and compressible parts. This can be accomplished by determining the points where pressure effects dislodgment, and then, by examination of the ridge, ascertaining in what manner and to what extent the parts yield under the plate. This done, the die should be carefully cut or scraped away at the parts representing these soft structures, preserving the general form as represented in the die, until the plate when in place shall so evenly compress these movable parts as to form an equal bearing on all the tissues, hard and soft alike. After cutting or scraping away from the die as indicated, make a new counter-die if necessary, and reswage; which operation may have to be repeated several times. In making these changes a zinc die is always to be preferred, as it alone will withstand the pressure of the repeated swagings incident to the process. It will seldom be found that a plate cannot be improved in its adaptation by scraping from the die at some part to admit of firmer bearing than would be obtained without such change. The extent to which it may at times be carried with increasing benefit to the plate has often been to the writer a great surprise. When the plate is so fitted *by swaging*, not by bending, that it will retain its place when reasonable pressure is made upon it from any direction, it is ready for the arrangement of the wax. This perfected die should be carefully retained, in order to try the plate on it from time to time during the subsequent stages of construction.

White wax is perhaps as satisfactory for making the wax articulation

as any of the compounds which have been recommended for this purpose. If the plate is warmed and a rim of wax pressed into place, and then melted on to the plate with a hot spatula, it will when hard adhere with sufficient tenacity to admit of all necessary trials in the mouth. The length and position of the required teeth should be accurately represented in the wax, and also with equal care the contour of the arch. Proficiency in this important process can be attained only by experience and careful study. The central line of the face should be marked in the wax, and any other markings made deemed helpful for arranging the teeth. The natural closure of the jaws should be secured, leaving the imprint of the lower teeth, natural or artificial, in the wax.

It would be manifestly out of place in this article to dwell particularly upon the matter of selecting artificial teeth. We may venture only to remark that the selection should be made to harmonize in shape, size, and color with the temperament and other characteristics of the individual. Facial expression may be preserved or restored by placing in their proper position in the mouth a set of teeth having a character in harmony with the wearer, or, as is frequently the case, absolute deformity may result from a selection or an arrangement of teeth unsuited to the individual.

Having selected the teeth to be used, their arrangement may be begun with the centrals or with the cuspids as may seem most desirable. If the cuspids are placed in position first, their cusps should fall between the cuspids and first bicuspids of the lower jaw, and the intervening space should be occupied by the centrals and laterals. The centrals should always be placed so as to stand in line with the centre of the face and incline toward each other. It is not well to form contrasts in size or color in these teeth, but any reasonable departure from regularity in position, size, or color will be tolerated in either the laterals or cuspids. It is generally well to break up the uniformity in color by substituting one or both laterals from another set, or by making a similar change with the cuspids. Spaces indicative of missing teeth may be made between the cuspids and first bicuspids, but to drop one of the six anterior teeth is to copy positive deformities. Teeth should be so arranged that when the lip is raised in speaking or laughing the incisors shall come more fully into view than the cuspids and bicuspids, and the teeth of the right and left side to appear of equal length.

Continuous-gum teeth, made especially for this work, with one long pin and a piece of porcelain extending from the tooth somewhat in imitation of a root, are the most convenient, but teeth made for celluloid work, with two pins and short roots, but otherwise similar to the regular continuous-gum teeth, may be used. The pin of a single long-pin tooth should generally be carefully bent at about right angles to the body of the tooth when, after cutting away the wax to give it room, it should be fitted into place. The porcelain root may be broken away with cutting nippers, small pieces at a time, until roughly fitted, and the corundum wheel used only for final adjustment.

It matters little how roughly the work of fitting the tooth in position may be done, provided that each tooth be made to rest against the plate at one point. The importance of having the teeth cut or ground so

as to touch the plate will become apparent on observing the behavior of a set during the fusing of the material. No portion of the root which can be made to occupy the space of the body or enamel should be carelessly cut or ground away, as it diminishes the quantity of body to be used, and serves to sustain and keep the tooth in position during the process of fusing.

The arrangement of the teeth completed in conformity with the plan of the articulating model, some colored wax may be loosely arranged over the roots of the teeth, to again form contour and to make a rough imitation of the gums for trial in the mouth. The position, pitch, regularity, or irregularity of the teeth may still be changed to suit requirements; and when this is satisfactorily completed the case is made ready for investing by removing all wax from the roots and from between the teeth, so as to present three surfaces of each tooth free for the investing material. The object of this is to enclose in the investient each separate tooth in a manner to hold it as firmly as possible, that none shall be moved or loosened in the process of staying and soldering. Whether anything shall be used upon the faces of the teeth to prevent etching the enamel while soldering will depend upon the manner of applying the heat. If they are to be soldered in a muffle under a high temperature, nothing will absolutely prevent etching, but they may be partially protected by applying first a coating of shellac varnish, and afterward covering with finely-ground silex mixed to a thin paste with water. The varnish burns away and the silex partially protects from the plaster. If they are to be soldered under the blowpipe—the only proper method for soldering continuous-gum work—nothing is needed to prevent etching, as no tooth can be etched in this manner.

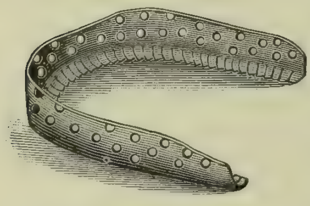
The investient is best made of coarse silex previously calcined, and strong plaster, in the proportion of about four to six parts of plaster by measure to one part of silex. A trial of other mixtures recommended for this purpose—for example, plaster and sand or plaster and asbestos —will cause an immediate return to the stronger and more enduring material here recommended. This investient, mixed with water, should be plastic enough to admit of being placed around and between the teeth, enveloping them thoroughly. While the investient should be laid on thick enough to admit of rough handling and some pressure, great thickness of the material is not essential and is an obstacle in heating. The thickest portions are required about the rim of the plate, as at this point the greatest pressure is made in staying, and it is here also that separation under heat is most frequent.

Not until the investient has become fully dry and hard should any attempt be made to remove the wax; which is easily accomplished after subjecting to a dry heat until the metal plate has become warm and the wax somewhat softened. In no case case should hot water be used for removing wax in connection with an investing material made of plaster and silex.

The process of staying a set of continuous-gum teeth will vary with the conditions. If the teeth are so arranged as to bring the long pin, where it merges from the tooth, near the plate, and thus admit of forcing a considerable portion of each pin into contact with the plate, such con-

tact will be sufficient staying. If, however, the teeth are longer or so situated that the pins when bent down will not reach the plate, or barely reach it, a strip or strips of plate will be required for more substantial staying and for strengthening the plate. Staying is best done with one strip of metal long enough to reach from the last molar on one side around under the pins to the corresponding molar on the other side. The thickness of this piece of platinum should be No. 29 United States gauge, unless it be quite narrow, when it may be lighter by one number. The pins should first be bent at right angles with the tooth, when the strip of metal should be fitted with some degree of accuracy to extend from the irregularities of the plate to the under surface of the pins where they emerge from the teeth, with about one-sixteenth of an inch surplus. The edge of the strip which is to touch the plate should now be cut comb-like, the cuts a little more than one-sixteenth of an inch deep along the whole edge. The slit portions should then be bent with pliers to a position at right angles to the body of the stay, and the whole shaped and trimmed until it will readily go into place under the pins, when it is ready for fixing permanently in position (Fig. 410).

FIG. 410.



Metal Stay for Strengthening the Plate.

Beginning usually with one end, it is put in position under the last molar, and the pin bent down to hold it in place; and so with each of the others in succession, the stay being forced solidly against each tooth and in contact with the plate. In bending the pins on to the stay to be soldered they should be forced to one side at an angle of about twenty-five degrees. By bending the pins in this manner the gold used for soldering is much more easily retained in place, and is also more likely to flow where desired. In soldering two pieces of platinum at any point in connection with continuous-gum plates care should be exercised to bring the parts to be soldered in *contact.* Pure gold or gold-and-platinum alloy is the only solder which can be used without impairing the color of the material (body and gum) when fused; and as gold at 2016° F. becomes quite fluid and tends to unite with the platinum, it fails to solder two pieces *not* in contact unless used in excess. A very small quantity of gold, when properly placed, will readily solder two pieces of platinum, and the smaller the quantity of gold used, if the soldering is complete, the better the final results.

The stay having been forced into position, and the pins bent down upon *it,* the little slit portions should be pressed down solidly against the irregularities of the plate, thus making quite perfect contact between the stay and the plate and the pins and the stay. The case is now made ready for heating by placing a small piece of gold, previously dipped in ground borax, on the upper surface of each pin, from which it will naturally run and unite it throughout its whole length to the stay. Condensed pieces of gold from old fillings will be found much more manageable for this purpose than loosely-rolled pellets of foil. The pieces for uniting the stay to the plate should be considerably larger

than those required for the pins, and are better applied singly and as wanted after the pins have been soldered. Question may arise as to the necessity for the use of borax in soldering platinum. While it may not be required to clear the surfaces of oxidation, it is yet so serviceable in retaining the pieces of gold in position while heating the case that it becomes practically a necessity.

A set of continuous-gum work may be heated for soldering in any manner desired—by gas, coal, or charcoal, but not in a highly-heated tooth-furnace. The soldering should always be done with a blowpipe, as it is the only way to properly direct and control the flow of the solder, and it is the only method by which etching of the surfaces of the teeth may be certainly prevented. If the case is first made ready for soldering in an ordinary coal-fire by being heated to a point approaching gold fusion, the flowing of the gold will be very readily accomplished with a good blowpipe, and especially if the operator understands pointing the flame. The best results will be attained by soldering the continuous stay to the plate throughout its entire extent, and each pin solidly to the stay. Any unsoldered pin or portion of the stay may readily be detected while the case is hot by directing the proper light upon it. If it be found when the case is cool that one or more of the pins of the teeth or any portions of the stay remain unsoldered, circumstances must determine whether to reinvest and reheat the case, or to attempt to apply the material with the teeth loose; though it should be remembered that a case thoroughly soldered gives much greater promise of satisfactory completion than one partially or imperfectly soldered. Excess of gold in soldering should be carefully avoided, but if for any reason it is found to exist when the case is cool, it should be carefully burred or scraped away. A quantity of gold sufficient to flow over the platinum plate in the subsequent heatings for fusing the material is very injurious to the case, such condition being a certain cause of "blow-holes" between the body and the plate.

When the case is soldered and cool, great care should be exercised in removing from under and about the teeth all of the investing material. Any portions remaining and incorporated with the body will certainly show in the completed case. To facilitate the disengagement of particles which may have fused to the teeth with the borax, as well as to remove the borax itself, the case should be allowed to stand for some time in the usual dilute sulphuric-acid solution or be heated for a few moments in the same.

The plate should now be returned to the die on which it was last swaged, where it should fit as accurately as before soldering. Any accidental deviations should be carefully corrected. It is well at this stage, while the plate is on the die, to roughen by fine scratches that part of the plate over which the porcelain material is to extend. This is done by holding the plate steadily on the die while with the sharp point of a good knife or an excavator-blade fine, close scratches, not deep cuts, are made. The point of the instrument should not be allowed to become dulled, as the object of this scratching is to roughen the plate, and thus furnish a better surface for the body to attach itself to in fusing. A dull instrument will bruise and stretch the plate, rather

than make the little furrows which follow the use of a fine, sharp tool. This operation has been pronounced superfluous, but after an extended experience in making continuous-gum work, and a trial of both methods, I unhesitatingly recommend judicious roughening of the platinum surface on which it is desired to fuse the continuous-gum material. After taking the case from the acid and thoroughly cleansing the plate should be kept scrupulously clean: even handling is injurious to it.

The materials used for fusing the teeth to each other and to the plate are known as "body" and "gum," and have been made at different times by experimenters with this work of differing materials and combinations. The earlier formulæ of Dr. John Allen and of Dr. W. H. Hunter were published in the dental journals soon after the introduction of the work by these gentlemen, and are still to be found in treatises on mechanical dentistry by American authors. As these formulæ have been superseded by more recent and improved compounds, they are of no present value, and their reproduction here would be superfluous. The author also published formulæ for continuous-gum body and gum enamel in the *Dental Cosmos*, vol. xi. p. 458, his object being to produce a material which would contract less in fusing than those then offered for sale at the dental dépôts. The difficulty and trouble incident to compounding and preparing this material soon led to its abandonment and the adoption of the body and gum prepared by Dr. J. L. Close. More recently, the S. S. White Dental Manufacturing Company has secured the latest improved formulæ of Dr. John Allen, and is now manufacturing a reliable and satisfactory material. There are two objections to Dr. Allen's continuous-gum material, and these in connection with the body: First, great shrinkage in fusing; and second, the tendency to the formation of "blowholes" under and about the teeth in connection with the plate or the pins. While the shrinkage cannot be overcome, it may be compelled, in a manner to be hereafter described, to follow certain lines; and a thorough understanding of the management of the furnace fire will reduce to a minimum the danger from "blowing." If the tendency to the formation of "blowholes" could be effectually overcome, this material, so satisfactory in other particulars, might justly be pronounced perfection. Its fusing-point can be readily reached; it is close and strong in texture, and the gum-color beyond criticism. Continuous-gum body or enamel as prepared is made ready for use by mixing it into a paste with water. The most perfect cleanliness should be observed in handling the material, as all foreign substances, such as dust, specks of plaster, or silex, incorporated with it surely appear, to mar the perfection of the completed case.

Perhaps the simplest and at the same time most difficult part of making continuous-gum work lies in the manipulation of the material, the body and gum. Its application to the plate and about the teeth to give strength to the case, to restore the contour of the face, and to reproduce the natural effect of the gums about the teeth, is a task easy for the artist, but exceedingly difficult for the novice. Only a few leading directions can be given for it. In commencing the application of the body a prime consideration is to get it packed solidly under and between the teeth and into all interstices wherever found. When the body has

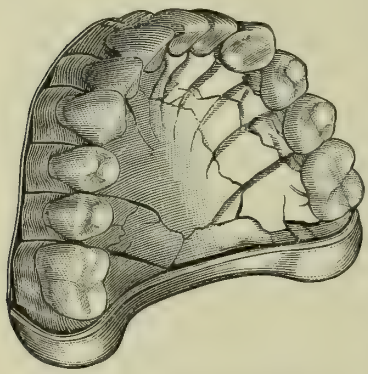
been mixed with water to a condition to be easily handled, it may be applied with a small spatula or other convenient instrument, first moistening the surfaces of the teeth and plate which are to be covered with water or with a thin mixture of the body, applied with a camel's-hair pencil. This will facilitate introduction of the body into the more inaccessible places between and under the teeth, and ensure its ready contact with the parts desired. After applying a portion of the material it may be condensed by gently rapping the plate, at a point where it will not be injured, with the wood handle of a small tool. Jarring the plate causes a more compact arrangement of particles, and brings the moisture to the surface, when it should be absorbed with a napkin. Applying fresh material and jarring the plate from time to time to condense it should be continued until the desired results are attained.

It was for some years my general practice to place the material on the case for the first heating about as full and heavy as the completed case was required to be, leaving contraction in fusing to make room for the gum-covering. This plan, I am satisfied, does not give as good results as that now adopted of placing only a small quantity of material about the teeth and plate—enough to fill solidly under and between the teeth and form a thin coating over the plate, without any attempt to give the proper fulness, the object being to fix the teeth and plate in the semi-fused material and to make union of the body and platinum surfaces more certain. It will be found especially advantageous not to place a thick coating of material on the inner sides of the teeth. While still moist, as a final preparation for the first heating the material under and immediately contiguous to the rim, which would prevent the free bending of it out or in, should be entirely removed, and separations formed between each of the teeth with a thin knife-blade. Commencing with the space between the molars, a clean cut should be made entirely through the applied material to the stay and the plate. This cutting should be repeated, externally and internally, at all spaces between the teeth. The object of these separations is to prevent movement on the part of the teeth and to arrest the formation of irregular, stringy cracks in the material—results which inevitably follow from contraction of the vitrifying body when no divisions have been made. These separations compel the material to shrink toward and unite with the teeth, leaving smooth and regular openings where the cuts were made, into which more material is readily introduced and made solid. This process completed, and all particles of material removed from the enamel of the teeth, the case may be dried and warmed as far as it can be in a stove or range oven, and thence conveyed to the mouth of the heated muffle, and gradually and carefully introduced into the hottest part. To the question, "How long shall a case be allowed to remain in the muffle?" only a qualified answer can be given. The time will depend entirely upon the heat of the muffle and the stage of construction of the case. The heat should be so regulated that about five to seven minutes will complete each baking after the set has been placed in the hottest part of the muffle. Less heat is required for the first than for subsequent heatings. Dr. Allen's material in fusing passes through a distinct *granular* stage, when the particles, beginning to unite, present a surface of incomplete

vitrification, readily distinguishable, either while hot or when cool, by its granular appearance. The heat should be carried to that point in the granular stage when, all shrinkage having taken place, the particles are just ready to drop into fusion, but still not fused. The case may be withdrawn from the muffle and examined, or turned around to regulate and equalize the heat, at pleasure without fear of injury. When sufficiently heated the plate should be withdrawn from the hot muffle and placed in a detached one with the mouth closed and allowed to cool gradually. Twenty to thirty minutes will cool a case to a condition for handling. The best and safest method of cooling is to allow it to stand in the cooling muffle until the latter can be handled at the hottest part, when the case may be quickly withdrawn and plunged into boiling water. Once in the water, the temperature may be rapidly reduced by the addition of cold water. This method of cooling may be adopted after each heating, and is much safer after the final fusing than that usually adopted of allowing the case to cool slowly in a muffle previously warmed.

After the first heating and cooling the case is ready for adjustment of the rim. Having been but partially turned in swaging the plate, now fixed by the semi-vitrified material, the rim is readily bent to any desired angle. This will be determined by the thickness of the material required for giving proper fulness to the face. The change is best made with thin, flat-beaked pliers and a riveting hammer. The rim should be turned without marring its upper surface, as the appearance of the case out of the mouth is much affected by the final finish given to it. The smooth and regular openings which result from the cuttings described after the first heating, as well as the space under the rim, are readily filled and made solid by first moistening them and then applying fresh material. Tapping the case with a wood handle from time to time will jar the particles into place and bring the moisture to the surface. After filling all spaces and cracks the material should be applied with reference to the appearance of the case in the mouth, the points where and the amount needed having been previously determined in the arrangement of the wax.

Fig. 411.



Shows a Case after the First Heating.

The method of heating the case the second time differs in no particular from the first. The heat should be carried fully up to, and possibly a little higher than in, the previous heating. Full vitrification, however, should not be reached. There is no positive test by which one may know just when the proper degree of heat is reached, but a pellet of pure gold may be placed in proximity to the plate and its melting watched. The first heating requires a temperature which will readily fuse the gold; the second, a little higher. A little experience will

enable the close observer to obtain readily the desired results from sight alone.

When the case is cool the second time it should be tried upon the die, and any change in adjustment corrected; after which it may be tried in the mouth, when the requirements of contour may be observed with precision and certainty. In difficult cases it is always desirable to try a set in the mouth at this stage of construction. Any modification desired may now be made by grinding off if too full at certain points, and adding if more is required at others.

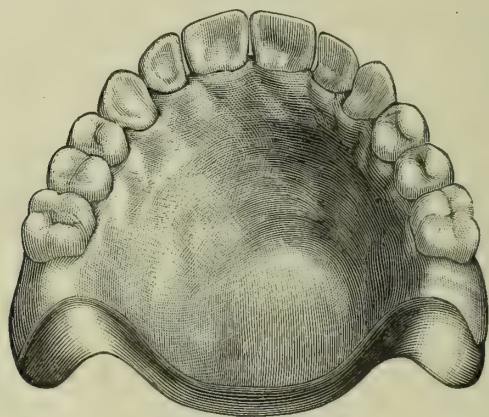
Partings of the material incident to shrinkage in fusing will still be observed, but usually not to an extent sufficient to demand a third heating for the body. Any wide cracks or any applications of new material to the surface to correct the contour will require a third heating, which is to be made in precisely the same manner as the second. Small cracks may be filled with the gum-enamel, which is made ready by mixing with water in the same manner as the body. The gum should be applied evenly over the fused body to about the thickness of a No. 22 plate, a little less being used over the palatine than upon the labial and buccal portions. The first heating for the gum requires more time before the muffle and more care in managing in every way than for any preceding heating. Little pieces are liable to be knocked or blown off, or defects from various causes to appear. When the heat approaches the fusing-point the gum parts and cracks, as did the body, with this difference: the cracks are not as wide, and under sufficient heat the gum will fuse and unite. Instead of pushing the first heating of the gum to the degree required to perfectly smooth the surface, it is better to withdraw and cool the case at the point where all the shrinkage has taken place and fusion is just ready to begin. At this stage any defects in enamelling, as failure to produce the required gum-shading at one or more points or to make close union with the rim, the withdrawal of the gum from about the neck of a tooth, or any other defects, are plainly recognizable, and are much better and more surely remedied by applying a little fresh enamel at the defective point than by attempting to complete the gum-fusion at a single heating. When cracks or other defects of whatever kind are remedied in the gum, there is no further difficulty in introducing the case into the muffle for a second heating of the gum, neither any necessity for over-fusion for the purpose of smoothing. The amount of heat required for the final fusing is most plainly registered on the case itself. The gum, under the strong, steady heat of the muffle, gradually settles down into a smooth, vitrified condition, when it should be immediately withdrawn. Every heating in the muffle demands careful watching, but none more than this last heating for the gum. At the proper fusing-point the gum-color is developed with that pleasing, life-like hue for which the continuous-gum work is justly celebrated. With the heat carried but a few degrees beyond the color begins to fade, its brilliancy is destroyed, and the strength of the case impaired. The strength and beauty of the completed case depend very largely on the manner in which the heatings for fusing the body and gum are conducted.

To recapitulate: the important points associated with the furnace-work are—No surplus solder on the plate or pins; no thick portions of

the material when ready for the first heating; so controlling the case that the first heating shall not fuse, only granulate, the material; the second heating a little greater than the first, and the third a little greater than the second; endeavor to complete the case with four heatings—two for the body and two for the gum; the final heating to smooth perfectly the gum, and still not *over*-fuse it. After the last heating of the gum the case should be placed in a detached muffle which has been previously warmed and allowed to cool gradually to a temperature not markedly above that of boiling water, when it should be withdrawn from the muffle without exposure and quickly plunged into boiling water, in which it may be kept, gradually reducing the temperature, a longer or shorter time according to convenience. It is well never to allow the case to become dry after plunging in the water until it is put in the mouth—a condition entirely possible to be observed in finishing the plate.

Stoning, polishing, and burnishing the plate have to do with its appearance rather than its utility. A perfectly smooth surface may be made for the band and the exposed palatine portions of the plate by first removing any adhering particles of the porcelain body or gum, or any special unevenness in the platinum itself, with a corundum file, followed by the Scotch stone. This leaves the metallic surfaces in the best possible condition for the final polish with brush wheels and burnishers.

Fig. 412.



The Completed Case.

Repair of Continuous-gum Work.

An objection frequently urged against continuous-gum work is that if broken it cannot be repaired. The fact is, that no dentures can be more surely, and none so completely, restored by repair. No breakage is too extensive for complete restoration, excepting only such injury as may demand a new plate. From one to the entire set of teeth may be broken, and yet the case restored without exhibiting any sign of repair. The accidents to continuous-gum dentures are usually the result of falls.

and consist in the breakage of one or more teeth, with possibly scaling of a portion of the material from the plate. To replace a broken tooth or teeth the remaining portion, together with the material investing it, should be ground away to the plate, or so much of it as will make room for placing a new and appropriate tooth in position. If the demands are for not more than two, possibly three, contiguous teeth, they will be securely held in position by the material alone, no soldering being required. The best results are attained by grinding away not only the remains of the broken teeth and the adjacent material, but the old material from all portions of the case, care being exercised not to injure the faces of the teeth. When this is done before placing the teeth in position it is best to anneal the case and drive off the organic accumulations by subjecting to heat in the muffle. A heat equal to redness will be all-sufficient for this purpose, and by resolving the case to the condition of a new one, and thus forestalling chipping and blowing, will amply pay for the time spent in this preliminary heating.

The teeth are now placed in position, and held there by packing carefully and as compactly as possible fresh body about them in imitation of the original condition. The case should now be placed before and in the muffle precisely like a new one receiving its first heating, the only difference being in the handling. It must be remembered that the teeth are held by the unfused material only, and that this when dry is extremely fragile. When once in the muffle and biscuited, there is no further danger of their moving. The first heating for this repair should be carried only to the point of complete shrinkage of the new material, hardly to a granular condition; the case should then be withdrawn, cooled, and the cracks carefully filled with body or gum, and other defects, if any, remedied. The extent of these must determine the necessity for a second heating before applying the gum-material. Usually, the cracks are filled and the gum-material applied as for a new case, the appearance and strength of which it possesses after receiving a second heating.

A more extensive breakage of teeth, as four to six, is better managed by removing, as before, all porcelain down to the plate, arranging and holding the teeth in place with wax, as is done for an original set, investing, staying, and soldering precisely as if the case were new. This will not injure any old material which may be on the plate, and will obviate the necessity of a preparatory heating in the muffle. When the teeth are soldered the further steps toward complete repair are obvious. Grinding away the old gum, although not a necessity, is always advisable, as it makes room for an application of fresh gum-material, which when fused presents the appearance of a new case.

The Construction of Lower Sets of Continuous-gum Work.

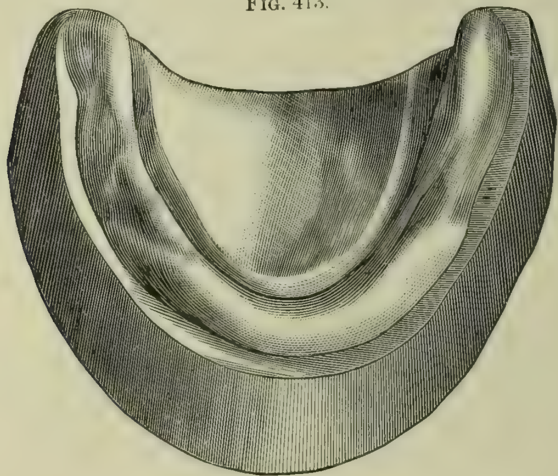
Certain modifications only require special consideration in the construction of lower sets, as the general process does not differ from that for the upper.

Commencing with the plaster impression, it will generally be found, if perfect, to adhere to the jaw with considerable force—a condition

which indicates its fitness for use. The impression of a lower jaw which has a fairly prominent ridge, for which a swaged plate is contemplated, may be manipulated before making the cast, with decided benefit to the case when completed. The groove in the impression representing the ridge of the jaw may be deepened throughout its entire extent, especially in its greatest depressions and along the less-yielding portions of the ridge. This should be done by carefully scraping from the plaster impression, without impairing its form, to a depth represented by the thickness of heavy wrapping-paper, and varying from this to that of blotting-pad. No change, however, should be made in the impression which would widen or deepen the ridge *at its base.* The top of the ridge only is to be modified by this operation. The slight enlargement thus given in the cast to the more prominent as well as the more unyielding parts of the ridge will provide for the inevitable compression in swaging at these points, and produce a plate more uniform and stable in its bearings.

The cast removed from the impression, a rim of wax or plaster should be formed on it at the base of the ridge to mark the boundary of the plate and to prepare for the partial turning of the platinum rim in

FIG. 413.



Cast of Lower Jaw ready for Moulding.

swaging (Fig. 413). Only experience and a thorough examination of the mouth can determine the line of this rim. If it is formed too high on the ridge, the plate will be deprived of surface and bearings essential to its comfortable retention in the mouth ; if it is formed too low on the base of the ridge, impingement of the plate and irritation of the tissues will be caused.

Dies for lower plates, as for upper ones, are best made of zinc with counters of lead.

The thickness of the platinum plate should not be less than No. 27, and for most mouths No. 26 United States gauge is better. This increase in thickness over that of upper plates is required to give addi-

tional strength to the completed case, as from the horseshoe shape of lower sets they are much more liable to injury from falls than upper plates. The material is also more subject to injury in mastication.

As the rim cannot be wholly adjusted on the die, it is good practice to solder a No. 18 or 19 platinum wire entirely around the plate in the groove made by partly turning the rim in swaging. A wire so soldered obviates the necessity for further adjustment of the rim—the edge of the plate requiring to be finished to this wire—and permits reswaging of the plate after soldering. It forms an excellent boundary for the material, strengthens the plate, and increases its thickness on the line where alterations are frequently required. If, instead of soldering a wire in the groove, it is preferred to completely turn the rim, it should be done when the teeth and plate have become fixed in the material, after the first heating, as in constructing upper cases.

When the plate has been fully formed the processes for constructing lower sets differ in no respect from those for upper ones.

Lower Sets of Continuous-gum Work with Vulcanite.

Many continuous-gum lower cases may be advantageously made with vulcanite adaptation, thus securing a lighter case and lessening the liability to cracking of the material. Lower sets so made have the appearance and the cleanliness of those with full platinum plates, and possess at the same time certain marked advantages secured by the adjustment with vulcanite.

To make a case of this kind a base-plate of gutta-percha should first be formed to the cast, and with this in position a set of dies should be made the same as from a naked cast. With these dies a narrow No. 29 or 30 platinum plate should be swaged, making no provision for a rim. This plate should be warmed and pressed gently into the gutta-percha base-plate on the cast, the wax articulation formed, and the arrangement of the teeth made upon it. When ready for investing, the base-plate should be carefully separated from the platinum plate and replaced upon the cast, and the plate and teeth stayed and soldered in the usual way. After soldering the plate and teeth may be returned to position on the base-plate, with which trial in the mouth may be made if desired. When the teeth are in satisfactory position the metal plate should be again separated from the gutta-percha, and the case treated as one having a full platinum base, care being exercised to keep it in adaptation to the die on which it was formed. After enamelling, a slight groove should be cut in the material just on the line of union with the plate to secure it in the vulcanite. It should now be returned to its place on the base-plate

Fig. 414.

Lower Set of Continuous Gum set in Vulcanite.

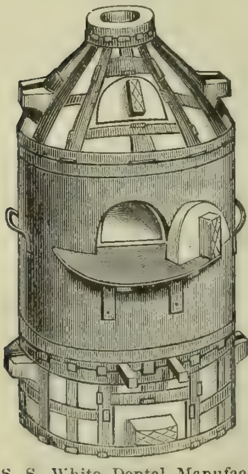
and cast, waxed into place, flasked, packed, and vulcanized. When finished the case will possess all the desirable features of the continuous-gum work, with the advantages of vulcanite for lower sets.

Furnaces, and their Management.

In the earlier history of continuous-gum work large tooth-furnaces, usually charged with anthracite coal, were alone used in fusing the material. Such furnaces, when placed to command a strong and steady draft, if properly managed, are satisfactory in their workings and results. Being made to carry large muffles, sets of teeth may be readily introduced, changed in position, and withdrawn without danger of touching their sides; and they furnish a volume of heat steady and continuous, which is a great desideratum in fusing ceramic compounds. The objections to them are frequent lack of draft, undue heating of the room from the large body of coal required to charge them, and the trouble and expense attending their firing. These furnaces are now so nearly superseded by the smaller and lighter ones designed to facilitate the construction of continuous-gum work that special directions for their use are deemed unnecessary here.

Since the introduction of coke as a fuel for fusing continuous-gum material the size and weight of furnaces have been greatly modified. They are still of the same general construction, but smaller and lighter, with a correspondingly small and thin muffle. In them sufficient heat can be readily obtained. The introduction of these small coke furnaces has removed the objections—difficulty of draft, excessive heat in the room, trouble and expense attending the firing—which belonged to the old tooth-furnaces, but without simplifying the work to any important degree. An illustration of the most desirable of these furnaces, made and sold by the S. S. White Dental Manufacturing Company, is presented in Fig. 415.

Fig. 415.



S. S. White Dental Manufacturing Company's Furnace.

These furnaces may be located to connect with any chimney having a good draft, but their surroundings should be fireproof, as the heat from them is frequently intense. The coke, the only fuel to be used in them, should be prepared in pieces about the size of an English walnut—not coarser, but if the draft is strong some pieces finer than this may be mixed with it. The successful heating of the muffle will depend upon three conditions: First, the draft; second, the preparation of the fuel; third, the charging of the furnace. To make a good fire there should be introduced into the furnace kindlings sufficient to light thoroughly a small body of coke placed on them, and time given to burn out the kindlings entirely before the furnace is fully charged. In introducing fresh coke, especial care should be taken to pack it solidly *underneath the muffle.* This is important, for two reasons: first, for

the support of the muffle; and second, to keep the body of the heat *below* the case, rather than at the sides or above it, as the material will be much more satisfactorily fused with the heat stronger under than it is over the muffle.

The furnace will require to be freshly charged with coke for each heating, as this fuel quickly consumes. The perfecting of the strength of continuous-gum work depends largely upon the furnace fire and the management of the case while fusing the material.

Gas Furnaces.

No furnace is suitable for constructing continuous-gum work which fails to produce a steady and certain heat, with capacity to vitrify both body and enamel perfectly. Volume of heat as well as temperature is required to give the full control of this work to the operator.

Several furnaces have been made within a few years for fusing continuous-gum material with *gas* alone. Reliable heating-appliances of this kind are greatly to be desired. They would obviate hindrances and delays and relieve the construction of this work of other unpleasant features. Some of the furnaces recommended for this purpose have fallen far below the requirements. Others more recently introduced, among which may be mentioned the "Verrier furnace," are meeting a favorable reception, and have been well spoken of; but the limited number of them thus far in use precludes at this writing an unqualified indorsement.

ARTIFICIAL DENTURES ON BASES OF FUSIBLE ALLOYS.

By THEODORE F. CHUPEIN, D. D. S.

There being several fusible alloys used as a base in the construction of plates for artificial teeth, these differing only in minute particulars in their formulas, it will only be necessary to describe the process for one, as the manipulations for all are practically the same.

It will likewise be needless to describe "the taking of the impression of the mouth" or the subsequent taking of what is termed "the bite" or natural occlusion of the jaws, as these subjects are treated in other parts of this work. We begin, therefore, with the model made from the impression.

For bases of fusible alloys the plaster of Paris of which the model is made should be incorporated with some finely-powdered pumice-stone. As a model for this style of work is not subjected to any heavy pressure, as is the case in celluloid work, it is needless to have the model very hard or strong; a porous but smooth model answers better. A well-stirred mixture of about one-eighth of fine-powdered pumice-stone with seven-eighths of plaster of Paris is made, and is then sifted into a bowl containing the necessary quantity of water to make it into a creamy mass. After the water has well saturated the mass the bowl is struck on its bottom to disengage all the air; the mixture is then, in small quantities at a time, conveyed to the impression with a teaspoon or spatula, beginning always at one side of the impression, and tilting and tapping this, so as to let the mixture run smoothly in every part, as well as to disengage any remaining air that may be in it. Before running the mixture into the impression, the impression, when taken with plaster of Paris, should be coated with thin shellac varnish, and when this has dried another coat of thin sandarac varnish should be applied. The application of sandarac varnish leaves a very smooth, glossy surface to the impression, which is reproduced on the model. It is not necessary to oil the impression before pouring the plaster and pumice mixture into it to make the model. By simply immersing it in clean water while you are preparing the plaster and pumice, and then shaking out any water that may adhere to it, you will be enabled to cast a very smooth model which will not adhere to the impression.

A model for this style of work need not be built up very high, as would be necessary in the case of a swaged plate, where dies would have to be made from the model to stamp up such a plate; a half inch

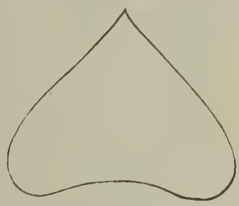
above the highest point of the palatine arch will be amply sufficient. The writer has found the following a very good plan for making a model: Take a strip of paper about two and a half inches wide by twelve inches long, and wind or wrap this all around the impression in the impression-cup. The paper is held close to the cup with the fingers of the left hand, and forms a convenient receptacle in which to pour the plaster. When the plaster sets sufficiently the paper may be unwound, leaving the model neatly made and requiring but little after-trimming.

The model is removed from the impression when the latter has been taken with wax by immersing all in a bowl of hot water of the temperature of 130° to 140° F. If the impression has been taken with modelling compound or gutta-percha, it may be immersed in nearly boiling water to remove the model; but if the impression be taken with plaster of Paris—which is always the most reliable material with which to take an impression—this has to be removed by carefully cutting it away, piecemeal, from the cast. Sometimes, however, especially in cases where no teeth remain in the mouth, a slight tapping of the impression or model with a light wooden mallet is sufficient to disengage the one from the other.

The Vacuum-Chamber.—If it is deemed necessary to make the plate with a vacuum-chamber, it is constructed as follows: A piece of thick brown paper is folded on itself, and the shape of the chambers traced with a lead-pencil on it, as indicated by Fig. 416. The paper is then cut, following the lines traced on it, and this when unfolded gives you a perfectly symmetrical pattern, as shown by Fig. 417. A piece of base-plate wax is now softened and neatly moulded over the entire face of the model. The paper pattern of the vacuum-chamber is then laid on this wax base-plate, in the position it is to occupy, and the form is traced on it. The pattern is then lifted off, and this part of the wax is cut out with a warmed wax-knife, leaving the model exposed. The exposed part of the model is then roughened and well moistened with water, and plaster of Paris and pumice-stone, mixed in the same proportions as for the model, are incorporated with water and poured into the space made by the cutting away of the wax base-plate, as has been described. When this has set so as to be quite hard, the wax base-plate is softened and lifted from the cast. The vacuum-chamber model is then scraped down to the proper thickness with an ordinary vulcanite scraper.

FIG. 416.

FIG. 417.



The vacuum-chamber should not be deep. It is preferable to have it large and shallow rather than small and deep. Indeed, many dentists who have considerable experience in making artificial dentures object to any central vacuum-chambers, and deem them useless. If they are used, the depth should not exceed the thickness of a piece of plate of the size of No. 16 of the standard plate and wire gauge.

The base-plate may be made either of gutta-percha furnished in thin

sheets for this purpose, or of base-plate wax, or of modelling compound, which also is prepared in sheets of suitable thickness. This latter material has the decided advantage of a rigidity which the other two materials do not possess. Much after-trouble will, however, be avoided if the base-plate is made of the pure tin-plate sold at the dépôts under the name of "pure tin for Stuck's method." This can be had of various thicknesses, so that the desired thickness of the future cast plate may be selected. A die may be quickly and readily made from the model, and the pure tin-plate is so pliable that it can easily be bent, moulded, and burnished to fit this die, which, for the sake of celerity, need not be cast of zinc, but may be cast of tin, which in a few minutes is readily melted in a sheet-iron ladle held over any of the Bunsen burners found in the laboratories. This base-plate of pure tin has sufficient rigidity, so that when the teeth are mounted on it, it can be conveyed in and out of the mouth without fear of displacing them. No. 20 of the gauge will be sufficiently thick for the base-plate, and the cast plate will not be thicker. Many of the fusible alloys in the market are only applicable for *lower plates*, because when cast as thin as is here specified they do not possess the necessary stiffness for an upper plate. Dr. George F. Reese, with whom the writer has had some correspondence on this subject, states that his formula for fusible alloy or "gold alloy for cast dental plates" has all the stiffness of a gold or silver swaged plate, and that it can be cast for upper plates very little thicker than gold or silver plates used for upper dentures. He also states that by his formula such a true equivalency of contraction and expansion is maintained that a glove-like fit is secured, and also all the advantages that a gold plate possesses in *conductivity*, *strength*, and *resistance to chemical action* in the mouth. This alloy is in color like nickel-plating. It is not brittle, but may be bent many times without breaking. It will not oxidize or turn black in the mouth. It melts at 600° F. In its galvanic properties it is decidedly positive to gold, very slightly positive to tin and tooth-substance. Its specific gravity is slightly greater than that of pure tin. Old plates of this alloy can be remelted and used again. It is suitable for partial and entire cases, upper as well as lower. It requires about the same amount of time to make a plate with this alloy as to make one of rubber, except when used with rubber attachments. The alloy has no taste. An upper plate of average size weighs about sixteen pennyweights. It can be readily, quickly, and beautifully repaired. All kinds of teeth can be used with it just as with rubber. It can be gilded if desired, and there is no waste, as all scraps can be remelted and used again. Dr. Reese uses only plaster for the models as well as for the investment.

If a pure tin plate of No. 20 thickness is used for a trial or base-plate, it is necessary to make a metal die, as, although thin tin is comparatively soft and pliable, to bend, mould, or burnish it upon the plaster model would so deface its fine lines as to make it unreliable afterward when the alloy is cast on it. Many dentists will object to the trouble of making this metal die. To such the following plan is suggested: Mount the teeth on ordinary base-plate wax, the same as for rubber work, and try them in the mouth. When they are found to be all

correct in position and expression, remove them from the mouth and replace on the model. Now cut away all the thick base-plate wax from the palatine portion, and replace this with thin wax, removing all superfluous wax from around the pins, and smoothing the case thoroughly before inserting. In cases of partial dentures where there are several isolated teeth, a gutta-percha base-plate would have to be employed, as base-plate wax is not sufficiently rigid.

THE TEETH.

All kinds of porcelain teeth may be used for this style of work. For ordinary cases the gum section-blocks or plain single teeth made for vulcanite or celluloid work may be employed. When the lower teeth approach so closely to the upper gum as to leave little room between the cutting edges of the lower teeth and the upper gum, teeth for metal-work have to be employed. It is evident in such cases that if vulcanite teeth were used the pins of these would be considerably ground away to accommodate the occlusion, which would not only impair the attachments, but interfere with the strength of the denture. In such cases, then, teeth for metal-work are used. The teeth are backed with gold or silver plate, and an extension or heel is left on the backing, so that this heel may be imbedded in the plate. Fig. 418 gives a sectional view of the tooth backed as has been described. This heel should be notched and punched with holes to make it hold to the cast plate (Fig. 419), as there is no adhesion between the fusible alloy and the gold or silver of which the backing is made. An adhesion, however, may be partially made between the heel of the backing and the alloy by tinning each extension with tinner's solder before waxing up the case to try in the mouth. It will be necessary before drying to remove every particle of wax from the extensions, and to paint them with the muriate of zinc or soldering fluid, as it is sometimes called.

FIG. 418.

FIG. 419.

Attaching the Teeth.—The teeth are attached to the base-plate with wax or a cement: the latter holds them more firmly in place. The cement is made by melting together gum dammar 7 parts, wax 4 parts: a half part of vermilion may, if desired, be used to color it. Before it is entirely cold it is pulled like candy with oiled fingers and formed into small sticks for convenient use. When gum section or block teeth (as they are sometimes called) are used, the sides or edges are carefully joined or ground to fit each other closely. If single or plain teeth are used, each tooth is stuck on to the plate separately in its proper position, so as to occlude properly with its antagonist. The superfluous wax is then smoothed, and the case tried in the mouth of the patient to see if the occlusion, position, and general expression of the denture are correct and pleasing. Many cases will look well and be all right on the articulator, but when tried in the mouth will look false, unnatural, and inartistic, while the articulation will be entirely different from what it was on the articulator. All these points or defects must be rectified

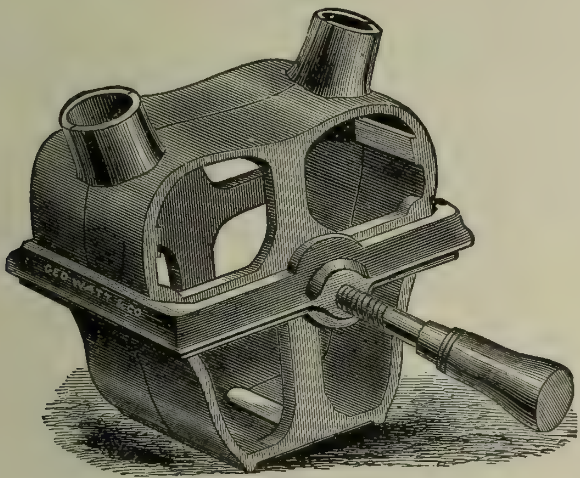
before the case can be proceeded with. The case being made perfect, the next step will be the

Waxing.—It is necessary when using any fusible alloy for an *upper denture* that it be made as light as possible, and for this purpose every superfluous particle of wax should be gotten rid of. The ordinary base-plate wax is entirely too thick to make an upper plate of fusible alloy with, and, although it may be used to mount the teeth on and try the teeth in, it cannot be used as a model for the cast plate without making it clumsy, heavy, and inartistic. If the plate be swaged of thick pure tin-plate about the thickness of No. 20 of the plate and wire gauge, and this be used to mount the teeth on, much after-trouble will be avoided; but if a base-plate of wax be used, as has been described, the manner of making the plate thin will be as follows: After the teeth are all in proper position countersink on the outer rim of the model four or more holes. These are varnished with shellac varnish, and are to serve as guide-places. These holes, as well as the outer faces of the teeth, are oiled, and plaster of Paris is mixed quite thick and poured into these guide-holes as well as over the outer faces of the teeth. When this plaster matrix has hardened it is cut through at its centre (between the central incisors) and the two halves lifted off. The whole of the wax base-plate that was used to try the teeth in may now be removed and replaced with two, or at most three, thicknesses of the thin wax used in making artificial flowers. This plate being made of thin wax, the fusible alloy which replaces it in the flask will come out just as thin. All superfluous wax may now be scraped off, and in this part of the work the time devoted to the careful removal of all unnecessary wax will be gained in the final scraping, filing, sand-papering, and finishing of the denture. When the wax prototype which represents the future fusible-alloy plate has been reduced by scraping with the wax-knife to the smallest dimensions consistent with proper strength, it is neatly smoothed over by short quick blasts of the mouth blowpipe, directed in and through the flame of a spirit-lamp. All inequalities both of rim and palatal surface being made quite smooth, the case may now be flasked.

Flasking.—In the opinion of the writer, the best flask for this work is the "Watt's moulding-flask," as illustrated in Fig. 420. It is well made and strong, having ample arrangements for the retention of the plaster and for the escape of moisture in drying. The two halves of the mould are separated, and into that half having the guide-pins the model is to be placed after it has been removed from the articulator. Plaster of Paris, mixed with fine-powdered pumice-stone in the proportions of three-fourths of the former to one-fourth of the latter, is sifted into sufficient water to form it into a thick cream and poured into that part of the flask indicated. The model, with the teeth mounted on it, may now be dipped into water, and then transferred into the plaster in the flask, and gently pressed downward until the plaster in the flask rises to the edge of the wax rim of the plate on the model. This may be made smooth and level with the aid of a small spatula, a wax-knife, or an ordinary knife-blade. When this has hardened, two small gullies are cut from the heels of the plate to each of the funnel-shaped openings of the flask,

and the surface of the plaster all around the teeth in the flask is varnished with shellac varnish. When this has dried it is oiled, and the other half of the flask set in position on the guide-pins. The funnel-shaped openings are now stuffed full of soft paper or cotton floss to prevent the escape of the plaster which is to fill this half of the flask. The screw and clamp may now be applied, so as to bind the two halves of the

Fig. 420.



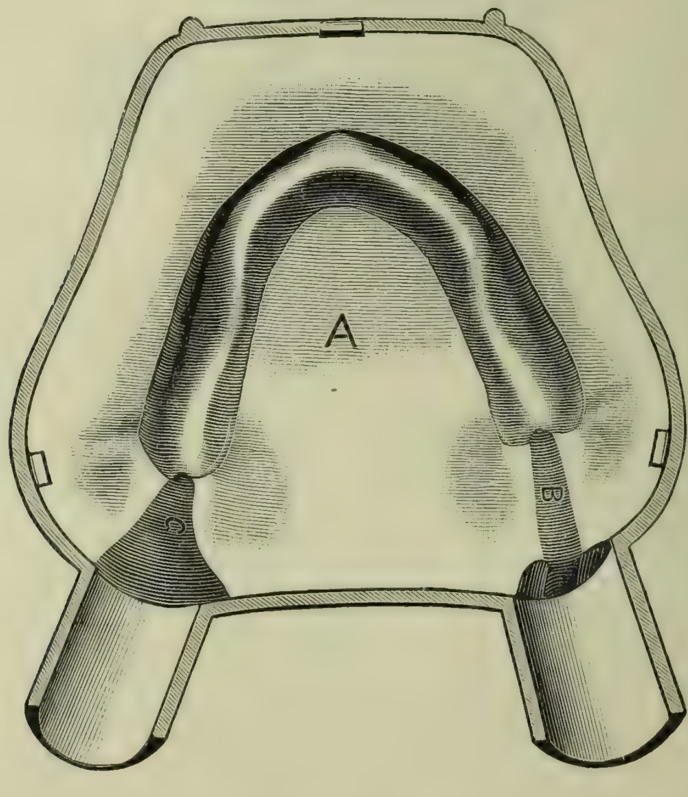
Watt's Moulding-Flask.

flask together, and plaster of Paris and pumice-stone, in the proportions as last indicated, are mixed and poured into the upper half of the flask. When this has hardened the clamp may be removed and the flask heated sufficiently to soften the wax. The two halves may now be parted and all the wax removed. The elevations made by the plaster in the upper part of the flask, running into the little gullies in the lower part of the flask, may now be cut down level. One of these gullies serves as a vent for the escape of air when the melted alloy is poured; the other, through which the fused alloy is to be poured, should be gradually increased in size from the heel of the plate to the full size of the funnel-shaped openings of the flask, so as to offer no impediment to the easy ingress of the fused alloy when ready. If any of the wax sticks to the pins of the teeth, it may be washed away by pouring a stream of boiling water from a kettle into that part of the flask in which the teeth are imbedded. The two halves of the flask may now be put together again and the clamp applied. It is then set in an oven or over a gas or coal-oil stove to dry. The drying should be conducted slowly, but must be thorough, for should there be any moisture in the plaster at the time of pouring the alloy, steam would be generated, the metal would splutter, and the whole case would be spoiled.

The thorough drying of the case may be ascertained by holding a hand-mirror over one or both of the openings in the flask. Should no sweat or moisture appear on the mirror, it will be safe to pour the alloy. The flask may be permitted to cool slightly before pouring the alloy.

If the pouring is attempted at too high a temperature, the alloy will not chill in the flask with sufficient quickness, and, as it finds its way through the smallest crack or opening, the melted alloy will run out between the two halves of the flask as fast as it can be poured in. It is a safe plan before pouring to imbed the flask in slightly-moistened moulding-sand or marble-dust, to prevent an accident of this kind. The flask thus imbedded, the alloy may be melted. It should be watched while melting, and not be allowed to get too hot, and should be poured as soon as the entire ingot is fused. The pouring should not be hurriedly done, and should cease as soon as the little venthole indicates that the mould is full by the rising of the metal in that opening. The case should now be permitted to cool thoroughly before any attempt is made to cut it out of the flask. When this is done, if care has been taken to remove all superfluous wax and to smooth the case well with the hot blasts from the blowpipe as recommended, it will require little filing or scraping. It is safer in filing, scraping, sandpapering, and finishing

Fig. 421.

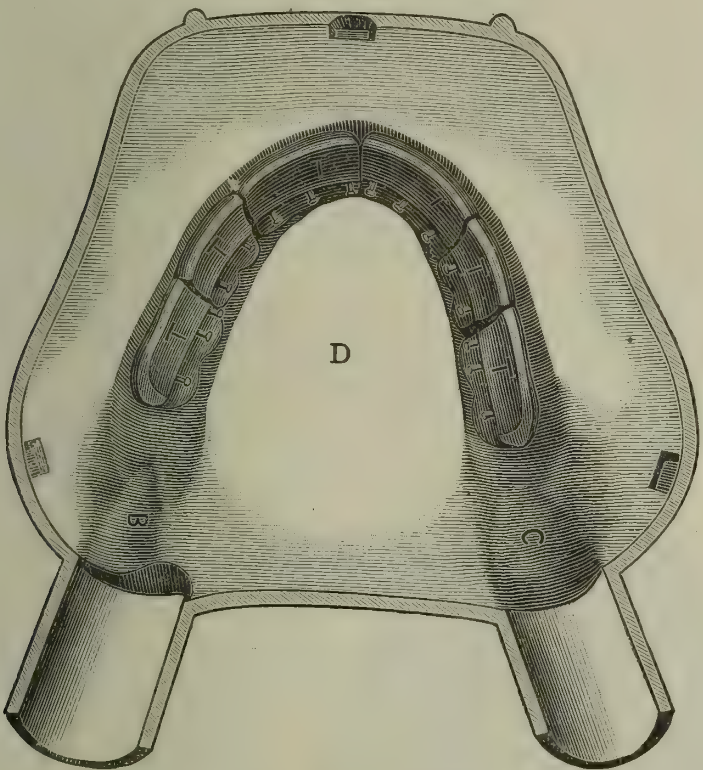


upper dentures to run some plaster of Paris in the inner surface of the plate, to avoid any danger of bending it during these processes. The palatal surface is now gone over well with fine sand- or emery-paper,

and all scratches removed from this surface as well as from the rim. It is reduced to a perfectly smooth surface with fine pumice-stone on cork wheels in the polishing lathe, and the final polish is imparted with whiting on a soft wheel-brush or buff.

Fig. 421 will illustrate a set of gum-section or block teeth which have been mounted for a lower case, and invested in the moulding-flask ready for pouring after the investment has been thoroughly dried. A shows the lower part of the flask in which the lower model is imbedded; B, the half of the air-vent; C, the half of the aperture into which the alloy is poured when melted. In Fig. 422, D represents

Fig. 422.



the upper part of the flask; T T T represent the gum-section teeth imbedded in this part of the flask.

Fusible alloys have been principally used for lower dentures where weight was thought necessary to retain the plate in place in consequence of the great absorption which so frequently occurs in the lower jaw (doubtless from the early loss of the lower back teeth), leaving little or no ridge for the retention of the plate in position.

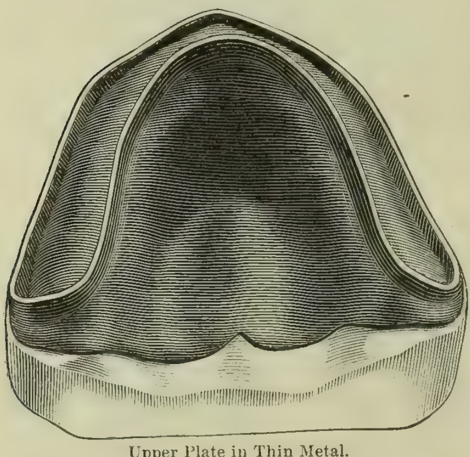
The manipulation for a lower denture when fusible alloy is indicated is precisely the same in its main features as that described for the construction of an upper. The same care should be taken to remove all

superfluous wax from about the teeth and in smoothing the case prior to flasking; but as a plate of this kind is used principally to be retained in place by its weight, the great care to secure lightness and thinness, as advised in the directions for making an upper denture, does not apply for a lower case. It should be understood, however, that judgment in this regard is to be exercised between too great and too little weight, between clumsiness and neatness.

Lately there has been a disposition on the part of the profession to avoid the use of the vegetable bases, such as rubber and celluloid, for plates, and to resort to metal, using gold, silver, or aluminum, and attaching the teeth to these plates either with rubber or celluloid. Some contend that a cast plate secures a more perfect fit than a swaged one. It becomes necessary, therefore, in the consideration of this subject, to describe the construction of a fusible-alloy plate for the upper jaw where it is designed to attach the teeth with rubber or celluloid.

The vacuum-chamber is formed on the model in the manner already described. On the model is traced with a pencil the height it is designed to run the plate without interfering with the fræna in the buccal border. This point should be well considered, for, the plate once made, very little of it can be cut away should it be found to run up so high as to chafe or cut the integuments. The shape of the future plate having been traced on the model, two or three thicknesses of the thin wax used in the making of artificial flowers are warmed and pressed all over the model. The wax is now trimmed down to the pencil-marks. A wax rim about one-eighth of an inch wide is now united to the labial or buccal parts of the plate, and carried backward nearly to the heels of the plate, running forward again, along the backs of the teeth, until the two ends of this rim unite at the median line behind the central incisors, so as to form an outer and inner rim within which the teeth are mounted. The space between this outer and inner rim should not exceed one-quarter, or rarely three-eighths, of an inch in width. The outer or buccal rim should incline *inward*, while the inner or palatine rim should incline *outward*, so as to make a dovetail or undercut of the two, by which the vulcanite or celluloid can be bound to the plate. Fig. 423 will better convey to the mind what has just been described. As has been said, this must be constructed of thin wax for the upper jaw, the rims aiding materially in stiffening the plate. When the plate is thus formed in wax, it is flasked in the manner already described and the plate cast. On cool-

Fig. 423.

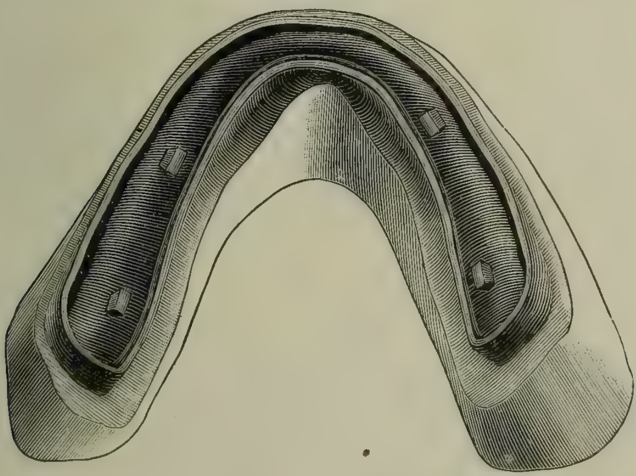


Upper Plate in Thin Metal.

ing it is removed from the flask and investment, and may then be filed to remove any roughness that may be on it. Articulating wax may then be put in the space between the rims, and the plate be put into the patient's mouth to obtain the "bite." This being secured, the plate is attached to an articulator, and the teeth mounted in the usual way. Either gum-section or plain teeth may be used. If the latter are employed, pink rubber or celluloid may be used to simulate the appearance of the gums. The writer would strongly recommend the employment of plain teeth and pink rubber, rather than gum-section teeth. He would not advise the use of celluloid, as his experience with this is that it shrinks, *even though constantly worn,* and leaves cracks or fissures between the rims which serve as receptacles for the accumulation of food, thereby making such a denture repulsive. No such shrinkage is observed where pink rubber is used, and the advances made in coloring rubber have of late been so great that a very close approximation to the color of the gum has been obtained with it. A very artistic effect may be produced by the employment of pink rubber and plain teeth, and the objections to the non-conductivity of an entire rubber plate are entirely overcome by the employment of a cast plate, such as has been described. When teeth are mounted on such a plate they may be flasked, packed with rubber, and vulcanized in the same way as an entire case of vulcanite.

A similar plate for the lower jaw may be constructed on the model in wax in the same manner as that described for the upper jaw. The employment of thin wax, however, is not indicated for the lower jaw, as a certain amount of weight is desirable for lower cases. The ordinary thickness of base-plate wax answers well for the making of a model of a plate for the lower jaw. Fig. 424 illustrates such a plate

FIG. 424.



for the lower jaw. The little projections within the rims are added merely as additional aids in holding the rubber to the metal plate.

Many patients seem to object to an entire denture of metal, as being

too heavy. This excessive weight is overcome by the employment of a cast-metal plate furnished with teeth mounted on the plate with rubber. The manner of construction of such a case for the lower jaw is the same as has been discussed for the upper jaw.

The fact has been noticed and discussed at dental societies that with certain persons—especially old persons—wearing entire artificial dentures there is a clashing or rattling of the teeth when the jaws are brought together which is very disagreeable to both wearers and listeners. Many devices have been resorted to to overcome this, but the most effectual has been on the part of the manufacturers of artificial teeth. Bicuspid and molar teeth are now made simply as a facing, so that vulcanite may be built up into antagonism to effectually overcome this rattling of the teeth, and offer a chewing surface sufficiently dense for all purposes of mastication.

The formulas for fusible alloys are mostly the secrets of manufacturers who have experimented in this direction. They are proprietary, and are therefore not obtainable. Dr. Norman Kingsley of New York has given a formula of metals which he has employed with great success and satisfaction in his practice. The proportions are as follows:

Pure tin	16 parts.
Bismuth	1 part.

The metals are melted together and cast into ingots for convenient use. Dr. Kingsley does not speak of this formula for upper plates, but only for lower. He says the alloy keeps its color in the mouth well, will not tarnish, and is susceptible of a high polish. The same author, while speaking on this subject, recommends the employment of *three parts* of fine sand to *one part* of plaster of Paris as an investment, holding that in these proportions the drying of the case is much more rapidly effected.

This article could not well be concluded nor the subject thoroughly treated were not a formula given of a good alloy for upper and partial dentures for such of the readers of this work as may feel disposed to make the alloy for themselves. To this end, the writer, after considerable search and correspondence, is enabled to lay before its readers a formula which is said to be reliable for these purposes. He is indebted to Prof. Charles I. Essig for the same, the formula being published in his work on *Dental Metallurgy*. The proportions given are—

Tin	20 parts.
Gold	1 part.
Silver	2 parts.

No directions are given for making the alloy, but we presume that in this, as in all other alloys, the noble metals are first melted and the base metal added, care being taken to prevent the oxidation of the latter. A quantity of borax should be used while melting the gold and silver to prevent the alloy from adhering to the crucible and to facilitate in pouring it into the ingot-mould for convenient use. The mouth of the crucible should be covered with a piece of charcoal or a layer of broken pieces placed within it, to prevent as much as possible the oxidation of the tin. It has been recommended that the mass be stirred with

a rod of steel or iron when the tin is added, so as to get a perfect union of the metals before pouring into the ingot-mould. Others claim that better results are obtained and a more intimate and thorough mixing secured by melting the gold and silver in one crucible and the tin in another, and then pouring the melted tin on to the melted gold and silver. One of the best arrangements for this purpose is one of the small reverberatory furnaces and bellows devised by Mr. Fletcher of Warrington, England, of which the cuts below give faithful delineations:

Fig. 425.

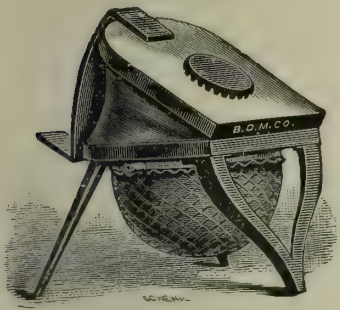
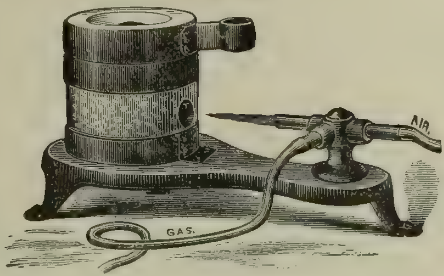


Fig. 426.



With this little furnace and bellows the most refractory metals are easily melted, it being claimed that a half pound of cast iron can be melted in ten minutes with a three-eighth-inch supply of gas.

ARTIFICIAL DENTURES ON THE RUBBER BASE.

By ALONZO P. BEALE, D. D. S.

Rubber Compounds.

Caoutchouc is a substance formed from the milky juice of the *Siphonia Cahuchu*, a large tree growing in Brazil and Guiana. It is insoluble in water and alcohol, but is soluble in the essential oils and in ether. It comes to the manufacturers in a milky form, and sometimes in a solid mass. When taken to the manufactory it is passed through a machine which mashes and tears it, while a stream of water flows through to wash it and remove all foreign substances. After this process is completed the caoutchouc has the appearance of tripe. It is allowed to dry, after which it is dissolved and the sulphur and coloring matter are added. In general terms it may be stated that the more sulphur added the harder the product, while a less amount of sulphur makes it softer and more pliable. Manufacturers refuse to make known their recipes for compounding dental rubbers, and the only formulæ obtainable are those of Dr. E. Wildman, which are as follows:

Dark Brown.	
Caoutchouc,	48 parts.
Sulphur,	24 "
Red.	
Caoutchouc,	48 parts.
Sulphur,	24 "
Vermilion,	36 "
Dark Pink.	
Caoutchouc,	48 parts.
Sulphur,	24 "
White oxide of zinc,	30 "
Vermilion,	10 "

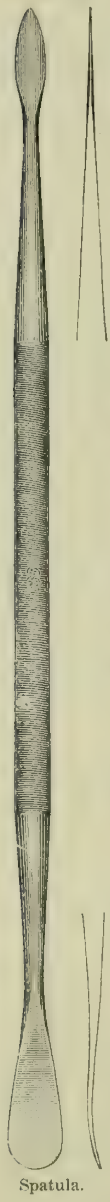
Grayish White.	
Caoutchouc,	48 parts.
Sulphur,	24 "
White oxide of zinc,	96 "
Black.	
Caoutchouc,	48 parts.
Sulphur,	24 "
Ivory-black or drop-black,	24 "
Jet Black.	
Caoutchouc,	48 parts.
Sulphur,	24 "
Ivory-black or drop-black,	48 "

Artificial Dentures on the Rubber Base.

The plaster model to be used in rubber work must be as hard as it is possible to make it with a good article of plaster; therefore great care should be observed in mixing the plaster. In pouring the cast or model air-bubbles should be avoided, the best method to accomplish this being to jolt the impression while pouring the plaster into it. When the model has been removed from the impression it should be shaped neatly

with a knife, and the vacuum-chamber model, if one is to be used, should be arranged. The mouth having been previously examined for soft spots, the face of the model should be trimmed accordingly. The next step is to make the base-plate—or model plate, as it is sometimes designated. There are many kinds of base-plates in use, but those made of paraffin and wax are preferable. Before shaping the base-plate the model should be dipped in water or be coated with liquid silex to prevent the plate from adhering to it. Soften the plate by heating, and press it firmly against the model, making it fit at every point. Trim off the surplus wax with a hot spatula, being careful not to mar the model. The plate can be strengthened by a piece of tinned iron wire, No. 15 Brown and Sharp American standard gauge, bent to fit the ridge of the base-plate, and waxed to it. This wire is very essential in lower base-plates. The articulation is taken in the same manner as for metal work, the plastic trial-plate in this respect answering the same purpose as a metallic one. In remodelling the features when they have been altered by the loss of the natural teeth, particular pains should be taken to obtain a pleasing expression, as well as to have the wax representing the teeth of the proper length and fulness. Place the casts in an articulator, being careful that the bases of the casts have been so trimmed as to be parallel with the line of the wax bite representing the cutting edges of the incisor teeth. In arranging the artificial teeth the wax that represents the proper fulness for the lip should not be disturbed, as the same fulness is to be reproduced in the rubber.

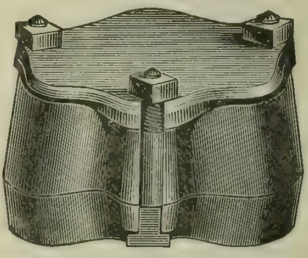
Fig. 427.



Spatula.

Either the teeth especially designed for rubber work and arranged in sectional blocks may be used, or single teeth with porcelain gums, the joints being at convenient places to give the proper shape and contour to the denture, may be employed. There are also teeth without gums, known as "plain teeth," which are used where the teeth are to rest on the natural gums or where the gums are concealed by the lips. In suitable cases these are preferable to gum teeth, because they are susceptible of a more natural and artistic arrangement. The gums can be made by the addition of pink rubber in sufficient quantity to hold the lip to the proper fulness.

Fig. 428.



Whitney Slot Flask.

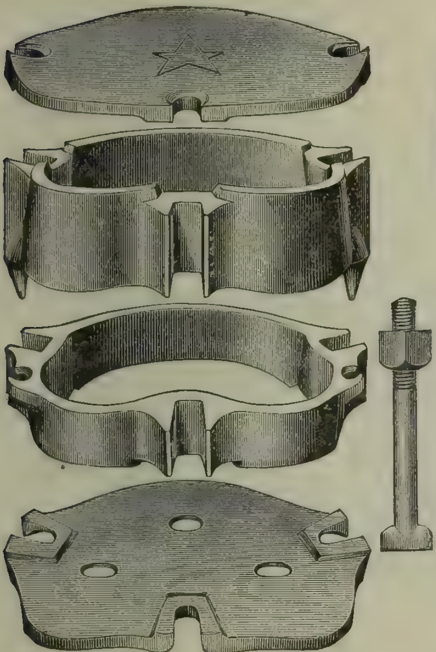
In the preparation of a full upper denture made of sectional block teeth care should be taken in jointing the gums to have the surfaces that come in contact so ground that they will fit perfectly and not form V-shaped spaces. As the grinding or fitting progresses each block

as finished should be cemented to the trial-plate, and so on until all the blocks are in their right position. The set should be shaped up neatly with a wax spatula (Fig. 427) to resemble as nearly as possible the finished set. The preparation of pink paraffin and wax is preferable for this purpose. Not a particle of wax should be allowed to run into the joints. The denture thus prepared should be tried in the mouth and altered if necessary. The wax trial-plate should be just the size and thickness purposed for the finished rubber plate.

After satisfactory adjustment in the mouth place the set on the plaster model, and run a hot spatula around the edge of the wax plate to make a perfect joint with the plaster. This prevents the plaster in the flask from insinuating itself between the plate and cast.

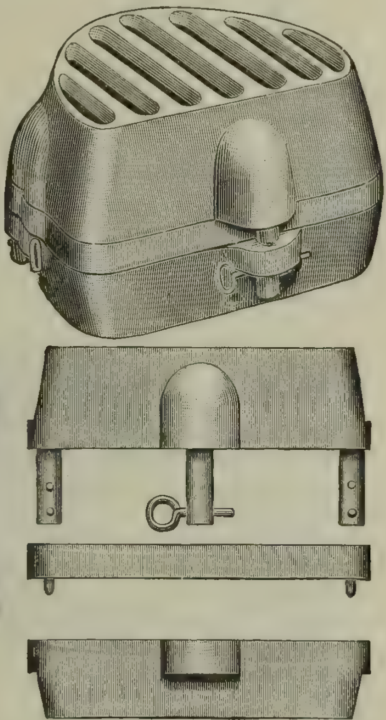
A flask is usually made either of iron, brass, or bronze. It is divided into two or more sections, closed by lids with or without perforations and

FIG. 429.



The Improved Star Reversible Brass Flask.

FIG. 430.



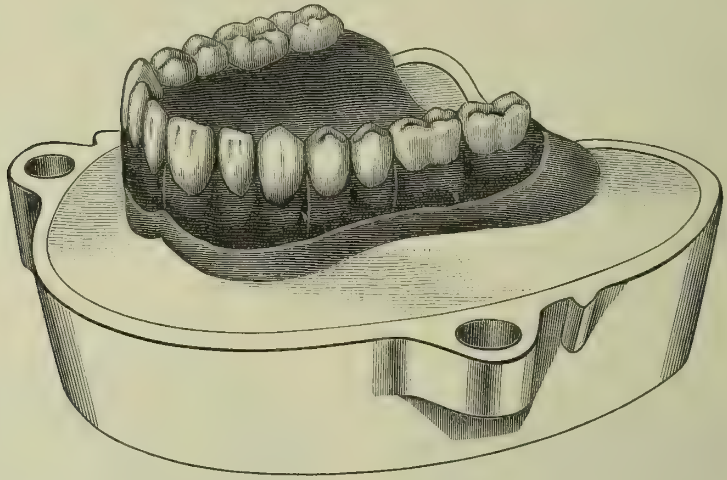
The Broomell Flask.

locked with pins or bolts. Figs. 428, 429, and 430 represent typical and standard forms. In using it is important to keep the joints clean and bolts well oiled to avoid friction. Before flasking, place the model and denture in cold water, keeping them there until the model is saturated; this prevents the absorption of water from the wet plaster in the flask, which would interfere with the proper placing of the cast. The water

also flows into the joints between the blocks, and thus favors the inflow of plaster at these points.

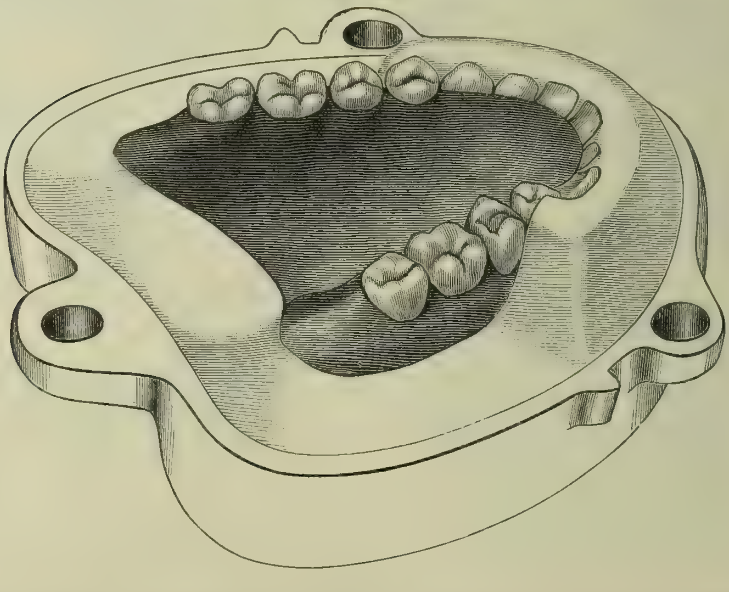
Plaster for flasking should be thoroughly mixed, and made of a thick

FIG. 431.



consistency. When properly prepared, partially fill the lower part of the flask and introduce the model, not horizontally, but slightly inclined,

FIG. 432.



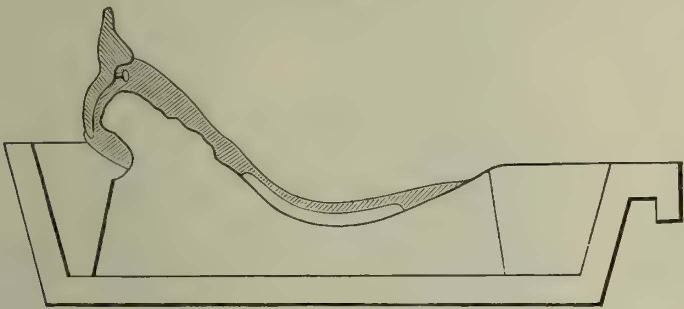
so that when it is forced down into its bed the air shall be excluded from beneath it. The height to which the lower section is filled with plaster determines the line of division between the upper and lower sec-

tion of the flask. Fig. 431 shows the proper position of the dividing-line for cases in which the bases of the teeth rest upon the trial-plate and the plate fits the plaster model. Such a division allows the teeth to be imbedded in the upper section of the flask.

For teeth whose necks are to rest upon the natural gums the division should be at the biting edges of the teeth, thus fastening them in the lower section with their bases in contact with the model. (See Fig. 432.)

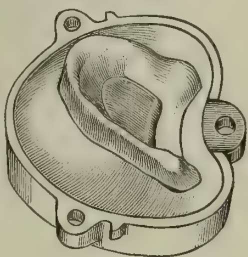
While the plaster is setting, trim the surface smooth, avoiding undercuts. Varnish this surface with shellac,[1] and when dry give it a thin uniform coating of oil or sandarac varnish,[2] to prevent the plaster in the upper section from adhering to that in the lower. Do not allow the

Fig. 433.



varnish or oil to come in contact with the teeth. Place the ring of the flask forming the upper section in its place on the lower section, seeing that no plaster is interposed to prevent the forming of a perfect joint. Mix the plaster as before and pour it into the ring, jolting the flask to force the air out, and also, when block teeth are used, to cause the plaster to pass into the joints. Fill the ring full; place the top piece in position; press it down firmly, forcing out surplus plaster, and allow it to remain until the plaster has set. In flasking a case upon a cast with a deep undercut in front, one of two processes may be adopted: First, the plaster in the lower section may be made to cover the wax rim within half a line of the porcelain gums. This will protect the cast, so that it will not be fractured when parting the flask or when packing the rubber. This method is represented in Fig. 433. Or the base of the cast may be so trimmed that the undercut will approach as nearly as possible the perpendicular, as seen in Fig. 434. When the latter plan is adopted the flask before opening should be moderately heated

Fig. 434.



[1] *Shellac Varnish.*
Gum shellac, 5 oz. avoir.
Alcohol (above 60 per cent.), 1 pint.

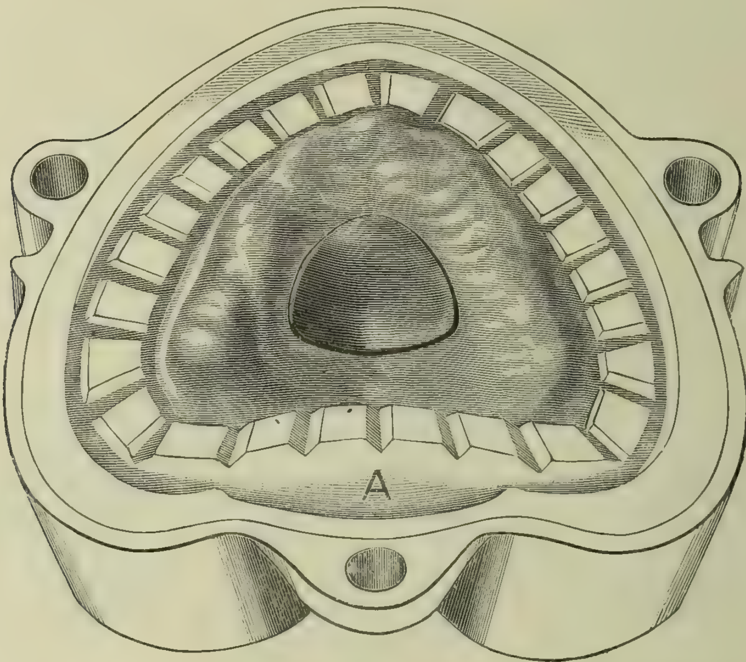
[2] *Sandarac Varnish.*
Gum sandarac, 5 oz. avoir.
Alcohol (above 60 per cent.), 1 pint.

in water to about a temperature of 120° F. Allow it to remain in the water for a few minutes, so that the heat may penetrate to and soften the wax. Then remove the flask and separate the two sections carefully. If these directions are followed, the wax will generally part readily from the teeth and plaster. If any adheres to the pins, it should be carefully washed out with boiling water.

The necessity for removing every particle of wax is due to the fact that its presence destroys the integrity of the rubber and interferes with its vulcanization.

The next step in the making of the case is to make outlets for the excess of rubber: this is done by cutting a groove around the cast midway between it and the margin of the flask, and then making all around radiating grooves about one-fourth of an inch apart, always cutting them from the cast to the encircling groove, as shown in Fig. 435.

Fig. 435.

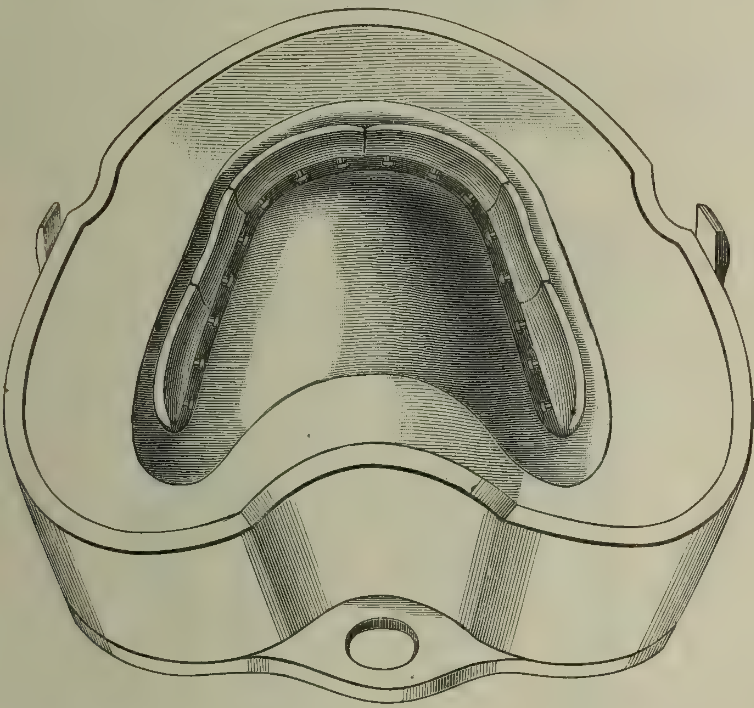


An excellent way to secure clean joints is to cut a large excess-chamber at the back of the cast to allow the surplus rubber to flow away from between the blocks. This is shown at letter A, Fig. 435. Another method to prevent the rubber from penetrating the joints is as follows: After the blocks are ground and properly mounted on the base-plate, remove alternate blocks, one at a time, and place a thin film of oxyphosphate or plaster of Paris on the joints, and then readjust the block. When the joints are all filled the case may be flasked in the usual manner.

Before packing the rubber the model and mould should be brushed to

remove all loose particles of plaster. The joints should be examined to see if the plaster has penetrated them; if not, pack dry plaster in them with a thin blade made of a discarded excavator; wet the plaster in each joint with liquid silex, instead of water, and allow it to dry. Fig. 436

Fig. 436.



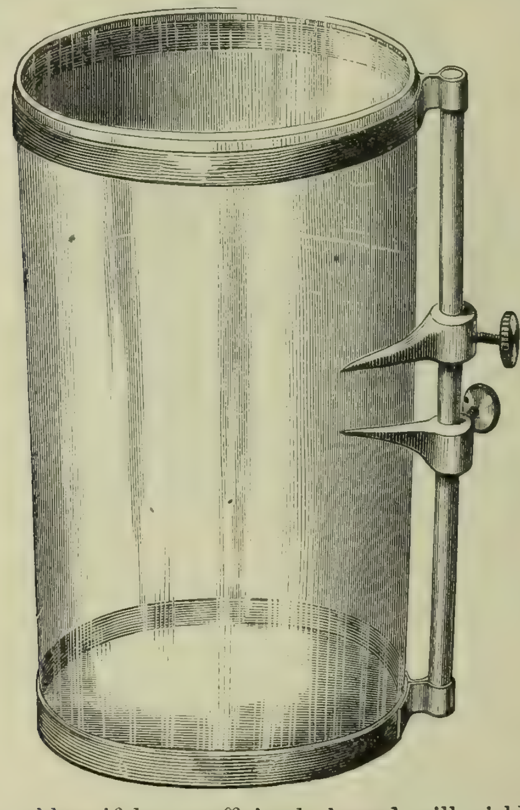
shows the upper section of the flask with the teeth in position. The mould should be coated with something to prevent the rubber from penetrating and adhering to its surface. Either tin-foil or liquid silex can be used. Liquid silex is preferable, because of its easy removal from the rubber in the finishing process. With a small brush give the model and mould a thin uniform coating of liquid silex, allowing it to dry before packing the rubber.

It is important to know the exact quantity of rubber required for the case. This is easily determined by displacement measure. As the wax is taken from the flask save every particle and make it into a mass, which should be submerged in water held in a narrow glass vessel (Fig. 437); note the point to which the water rises, then remove the wax, and place in the vessel enough rubber to bring the water to the same level, and for additional security a small extra piece to ensure having a quantity sufficient to fill every part of the mould.

In packing the rubber one of the most important considerations to be noted is that the mould, instruments used, and rubber shall be perfectly clean. Cut the measured quantity of rubber into narrow strips

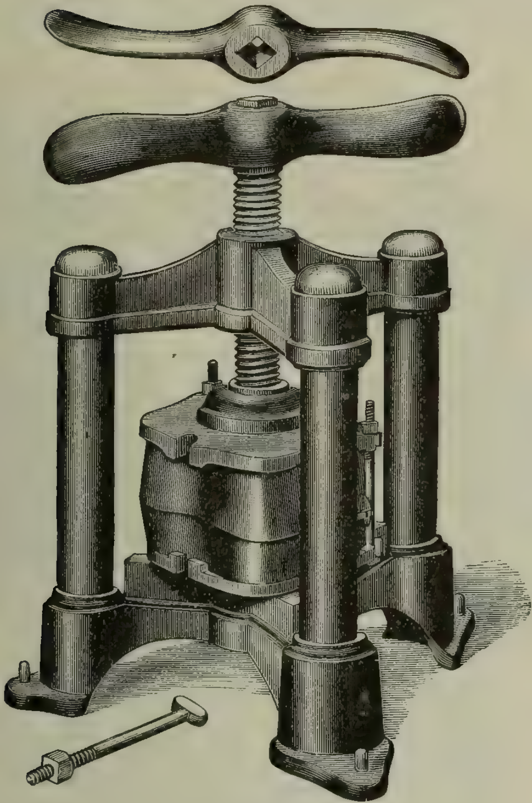
about one inch in length, and in small squares, and soften upon a metallic surface heated, preferably, by boiling water. Direct contact with an open flame is entirely inadmissible. When the rubber is thoroughly softened take a small smooth instrument and pack the narrow strips around the pins and into the small recesses; then with a larger instrument proceed to fill the mould with the square pieces, using sufficient pressure to consolidate it as added, care being taken not to enclose any air-bubbles or particles of plaster. Avoid packing full against the porcelain gums, especially when they are thin and come near the model when the flask is closed. Make the centre of the plate fuller than the remainder of the mould, and as the sections of the flask are brought

Fig. 437.



together the rubber, if kept sufficiently heated, will yield and flow in and around the more fragile portions of the case without danger of fracture. The mould being packed, the two sections of the flask are brought together, the bolts placed in position, and the screws turned enough to compress the rubber slightly. Although rubber is plastic, yet such is its nature that it will not yield to the sudden application of force as well as to continued firm pressure; therefore place the flask in boiling water or in an oven, frequently but gently tightening the screws until the sections are brought together. When the flask is closed the

FIG. 438.



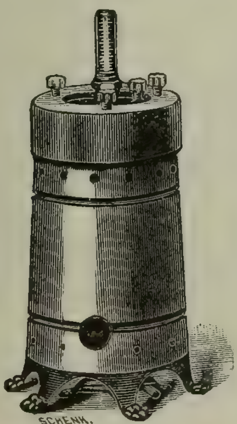
The Handy Flask-press.

bolts holding the sections together should not be removed until the work has been vulcanized and has become cold. A convenient method of closing flasks is by using a flask-press (Fig. 438), after which the bolts can be introduced. Undue force must not be exercised in bringing the sections together, as in so doing the blocks might be fractured or pushed out of position.

FIG. 439.

Whitney's Vulcanizing Machine.

FIG. 440.

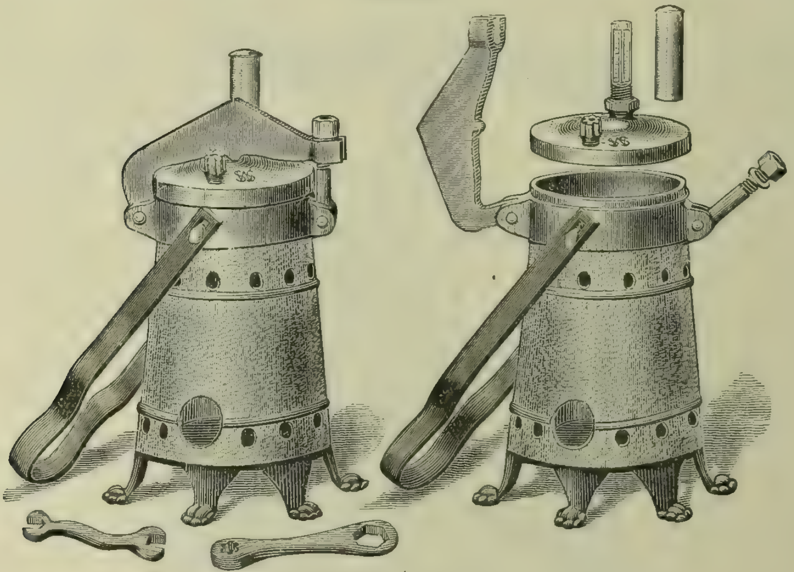


The Hayes Vulcanizer.

Vulcanizers.—There are many forms of vulcanizers in use, illustrations of six of which may be seen in Figs. 439, 440, 441, 442, 443, 444, 445, 446.

Fig. 441 represents the Mann vulcanizer, by which, by means of the improved method of fastening on the lid, the operations of closing and

FIG. 441.



The Mann Vulcanizer.

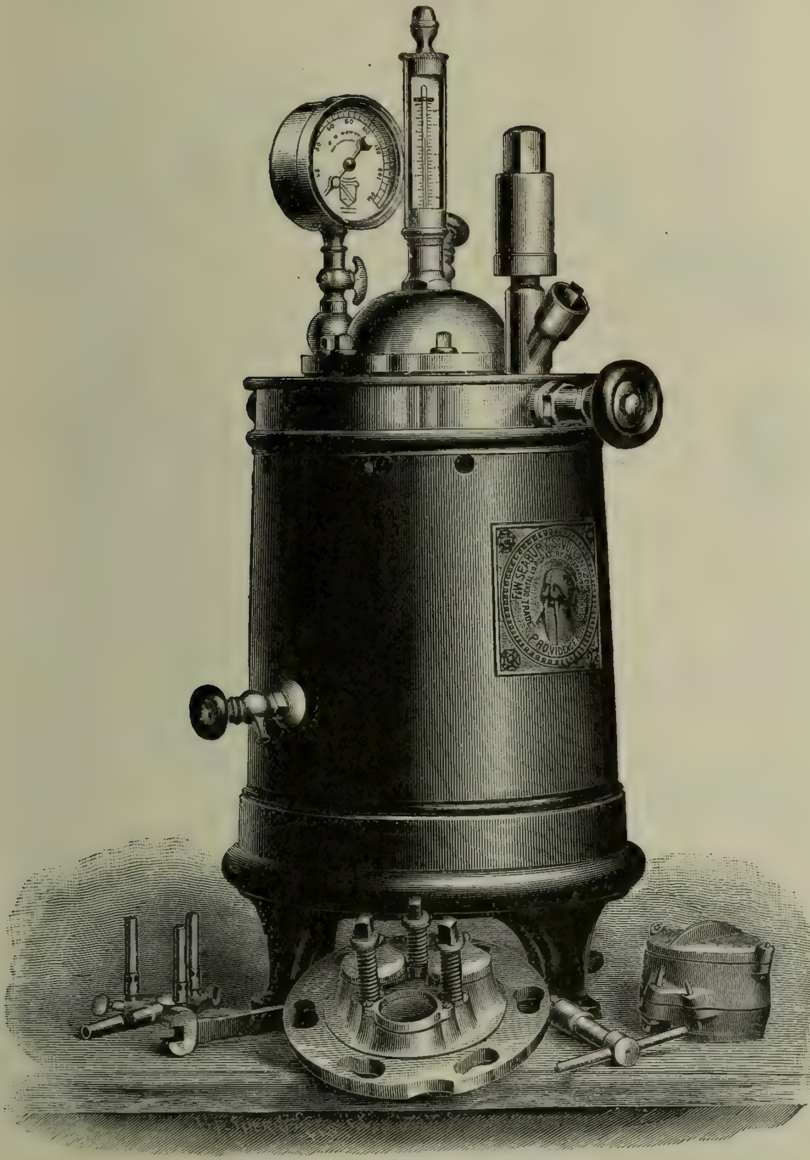
opening the vulcanizer are greatly facilitated. The lid, instead of being screwed on to the boiler, is fitted neatly and rests on a shoulder formed on the casting, and is secured by a heavy steel clamping-bar and screw-bolt. One end of the bar is hinged to the side of the boiler, the other end being slotted to receive the screw-bolt, which is hinged to the other side of the boiler. Rubber packing between the lid and the shoulder on which it rests makes the joint steam-tight. The lid is removed by unscrewing the nut of the screw-bolt a turn or two, when the bolt drops out of the slot and the bar is turned back, leaving the lid free to be removed. This method, while it gives as perfect a fastening as the usual plan, affords very much greater facility for opening and closing the boiler. Should it stick by reason of the packing becoming chilled (a common occurrence with all vulcanizers), it is easily pried off with very much less trouble than is required when the top screws on.

The vulcanizer is provided with a bail, a simple but heretofore unthought-of device, which greatly facilitates its handling, especially when hot. It is useful in removing the boiler from the jacket, in tightening or loosening the screw-bolt when closing or opening the boiler, and at all times when the boiler is to be lifted. When not in use it is readily removed.

Figs. 442, 443 represent the Seabury vulcanizer and celluloid press, concerning which its inventor makes the following claims: "It will enable the intelligent dentist, who does not wish to be restricted to the use of one plastic material, to accomplish results never before attained. Rubber and celluloid can be manufactured with this apparatus in less

than half the time usually required, and a perfect product assured every time. Both rubber and celluloid come out of the vulcanizer

Fig. 442.



The Seabury Vulcanizer and Celluloid Press.

finished. Cases may be removed from the oven and others inserted at any time during the process of vulcanization with a delay not to exceed five minutes, which is a great saving of time, especially with repair work."

Fig. 443.

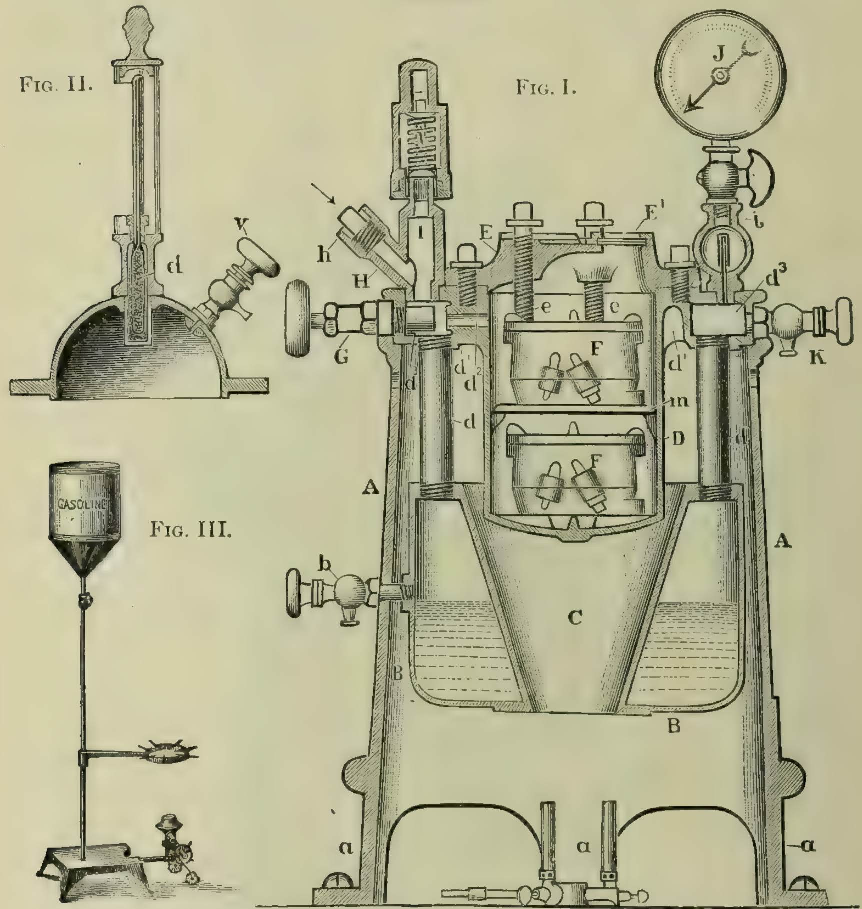


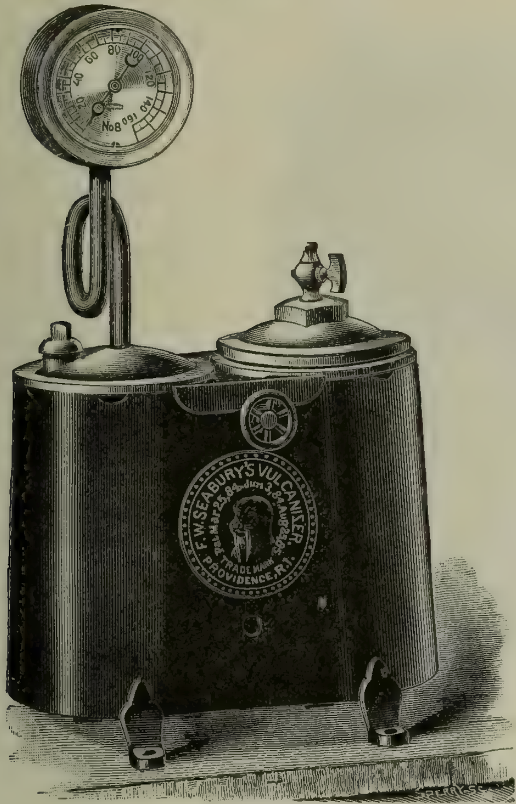
Fig. I. illustrates a transverse vertical section of the Seabury improved vulcanizer with dental flasks in position. A designates the hollow body of the vulcanizer, which is supported on the legs a Within this body is placed the boiler B, which is formed with the central inverted truncated conical flue C. The boiler and flue are supported by the tubes d, which are connected at one end to the top of the boiler and at the other end to the chamber d^3. D designates the oven, the lower end or base of which extends somewhat downward into the upper end of the flue C. The upper end of the oven is formed with lateral flanges d^1, which rest upon the top of the case or body A, and thus support the oven in position, and also form the top of the vulcanizer. E designates the pressure-cover of the oven, which is secured in position by bolts as shown. e e designate presser-screws, which work through square threaded sockets in the cover and press upon the flask F in the oven supported upon the disk m. E^1 designates two lids, which are pivoted upon the cover in such manner as to be readily removed, and by uncovering apertures in the cover permit visual access to the interior of the oven. G designates a valve which is seated in the flange d^1 of the oven, so as to close the channel d^2, leading from the pipe d to the interior of the oven. H designates a spout; the outer end of it is tightly closed by the cap h, which leads into the tube I, entering the chamber d^3 from above. The purpose of this spout is to convey water to the boiler B. i designates a pop safety-valve, which is seated on the upper end of the tube I. J designates a steam-gauge connected by the siphon-cock j to the chamber d^3, into which the tube d opens. K designates a test-cock communicating with the chamber d^3, and b designates a similar cock communicating with the boiler B on the water level.

In using this vulcanizer a gas or gasoline burner is set beneath the boiler B, and the valve G is closed, but the test-cock K is not closed until the escaping steam shows that all of the air is out of the boiler. The heat from the burner will ascend through the flue C, and will act directly upon the bottom and sides of the oven, thus heating the oven and water, which has been previously placed in the boiler at the same time or separately.

Fig II. illustrates a vertical section of the solid cover, which is used at all times except when closing the flask, and occupies the same position on the vulcanizer as the pressure-cover E. It is provided with a very sensitive thermometer, immersed in a mercury bath d, which projects into the oven D, and a test-cock v, used to let the air out of the oven before vulcanizing and to blow the steam out through after vulcanizing. The bar wrench is to be used on the cover-bolts only, and must never be used on the presser-screws e e, for which the T wrench is provided.

Fig. 444 shows a more recent invention of Dr. Seabury It consists of a boiler, with a steam-gauge above, and a plug in the top through which to supply water, connected by a globe-valve to an oven or vulcanizing chamber which has a capacity of three flasks. The blow-off

FIG. 444.



The Seabury Dry-Steam Vulcanizer.

cock is in the centre of the cover. The process of vulcanizing is the same as with the vulcanizer represented in Fig. 442.

Fig. 445 shows the New-Mode machine, and Fig. 446 gives a sectional view of its working parts and shows its construction at a glance. It is a cylindrical cast vessel having two chambers, one within the other, the inner one being supported by piers or columns connecting its sides, top, and bottom with those of the outer chamber, the whole being made in one casting. The outer compartment is the steam-chamber or boiler, and encloses the hot-air or packing-chamber on all sides, except the front, where the walls of the two chambers converge and become one, for the purpose of permitting access to the packing-chamber. A door, made of the same metal as the boiler and fitted with lead packing to make it steam-tight, is held in place by a bridge secured with screws. The door is also provided with a plate-glass light (shown in Fig. 445),

through which the operator can watch the progress of the moulding in the oven. The only communication between the two chambers is by means of a valve having its seat in the top of the packing-chamber, and controlled by a hollow stem which passes through the top of the machine. In regard to the merits of this machine the inventor makes the following statement:

Fig. 445.

"Two of the principal objections to the use of rubber as a base for artificial teeth have been that, as manipulated in the past, it was liable to creep and shrink from the teeth, leaving a space in which particles of food and saliva collected, and that it could not be permanently colored to represent the natural gum, and therefore could not be used satisfactorily except in connection with gum or block teeth.

"As to the first objection, its reality becomes at once apparent on removing the blocks from a plate that has been worn and observing the spaces between the teeth and plate filled with a mass of decayed food-débris. The cause of these spaces is that hard rubber in cooling from a temperature of 320° to that of the atmosphere shrinks very much more than any metal. Now, if it be considered that a plaster cast and investment, after boiling for sixty minutes in sulphuretted hydrogen water, are so soft that portions can be readily removed with the finger-nail, it will be apparent that they cannot hold the vulcanite in form while cooling; but, on the contrary, the softened plaster will yield to undue pressure from any cause, and thus allow the rubber to warp out of shape.

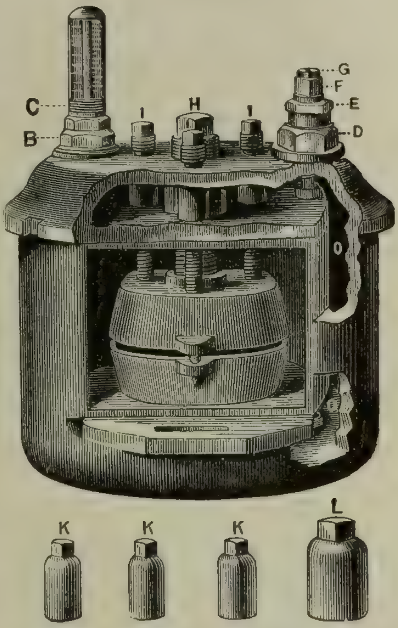
"This objection is overcome in the New-Mode machine. There is no shrinkage or 'creeping' of the rubber from the teeth. The plaster cast and investment are as hard and firm after vulcanization by the New-Mode in live steam as when first placed in the machine. If steam be excluded and sufficient time be taken, the rubber will adhere firmly to the surfaces of the teeth and hold them, even without pins—proving that there is no shrinkage or 'creeping.'" The following are the directions given for vulcanizing rubber with the New-Mode heater:

"*To Vulcanize Rubber.*—Make the cast and investment as in ordi-

nary work. The flask may be heated and packed in the oven; when this is completed, close the machine and cover the screws for closing the flask with the caps, to make them absolutely steam-tight. Raise the steam-valve and admit the steam to the packing-chamber. After the heat has been raised to 320° allow the case to remain in the hot-box at that temperature one and a half hours."

Care of Vulcanizers.—Vulcanizers should always be cleaned inside and outside after using. About once a year the boiler should be tested by giving it hard taps all over with a small hammer. If any point in the copper yields under the hammer, it indicates a thin spot which should be repaired at once. The packing for the vulcanizer is made of two or three layers of vulcanized rubber with thin cloth between them. It is cut in narrow strips suitable to fit in the groove provided for the purpose in the lid of the vulcanizer. Place the flask in the vulcanizer with the water just covering it. For two or three flasks the same quantity of water should be used as for one flask. Place the top on the vulcanizer and screw tight. The time expended in raising the temperature should not be less than half an hour, and when there is a thick mass of rubber the time should be extended to one hour, and sometimes more. If the heat is forced up too rapidly, it will cause the rubber to become porous or spongy. In the vulcanizing process a constant discharge of sulphuretted hydrogen and other sulphuretted gases takes place; this must escape through the pores of the rubber. From soft elastic rubber this is very easy, but it is more difficult from hard rubber or gutta-percha, the pores

Fig. 446.



B, thermometer-bath (it should be kept supplied with free sand or iron filings sufficient to cover the bulb of the thermometer); C, thermometer; D, screw-plug through which the compound faucet or steam-valve works; E, jam-nut for tightening the packing of the steam-valve; F, stem of the steam-valve, which works on a sharply-pitched thread, so that a partial turn is sufficient to seat the valve. It is packed with candlewick saturated with tallow, and is made steam-tight by screwing down the jam-nut, E. Should this nut screw entirely down without making the stem steam-tight, more greased candlewick should be added to the packing. The seat of the valve is countersunk in the top of the hot-box or packing-chamber. In the centre of the valve-seat is a small aperture through which, by raising the valve, steam is admitted into the hot-box. Corresponding to this aperture a hole is drilled through the whole length of the stem. At the top of the stem is the screw-cap G, with one side of the screw flattened to allow of the escape of the steam from the hot-box when desired. To dry the packing-chamber the valve is closed and the screw-cap, G, is either removed entirely or raised sufficiently to allow the steam to escape. The latter is the usual method in drying a cast. H, large screw for closing the flask; I, I, I, smaller screws for the same purpose. All these screws pass through the columns connecting the top of the packing-chamber with that of the boiler. They should be used very lightly with the wrench. The inventor uses the large screw merely to start the moulding, and occasionally to level the flask, depending on the smaller screws for most of the work. The smaller screws are especially useful to assist at the close of an operation or to close the flask on one side or the other or in front, to avoid breaking down the front of the cast in cases of deep undercut. K, K, K, L, nickel-plated caps for the screws. They are used only in vulcanizing by steam to make the screws perfectly air- and steam-tight. The packings of these and of the thermometer-bath and its screw-plug should be kept free from dirt and grit.

of which on the surface portion are very close. As a consequence the mass is liable to become porous in the thick portions and the plate warped.

When the vulcanizing point, 320° F., is reached, lower the flame so that the temperature shall remain uniform until the end of the operation. The time during which the heat must be held at 320° F. in order to effect vulcanization varies with different makes of rubber. The usual time is from one hour to one hour and a quarter. Black rubber requires the same time as the red variety, but pink rubbers, owing to the large amount of foreign matter which they contain, may be heated more quickly, and when 320° F. is reached they can be vulcanized in from thirty to forty minutes.

The fact should be borne in mind that a vulcanizer is subject to the same laws and conditions as a steam-boiler, which it is in fact, and, although it is safe and easily operated, it may, by a little carelessness or ignorance in its management, become almost as dangerous as a bombshell.

Table of the Elastic Force of Steam (French Academy Experiments).

Degrees of Temperature, Fahrenheit.	Elastic Force in lbs. per square inch.	Degrees of Temperature, Fahrenheit.	Elastic Force in lbs. per square inch.	Degrees of Temperature, Fahrenheit.	Elastic Force in lbs. per square inch.
212.	14.7	314.24	80.85	374.00	176.4
233.96	22.05	320.36	88.2	380.66	191.1
250.52	29.4	326.26	95.55	386.94	205.8
263.84	36.7	331.70	102.9	392.46	220.5
275.18	44.15	336.86	110.85	398.48	235.2
285.08	51.45	341.78	117.6	403.82	249.0
293.72	58.8	350.78	132.3	408.92	264.6
300.28	66.12	358.88	147.	413.78	279.3
307.05	73.5	366.85	161.7	418.46	294.

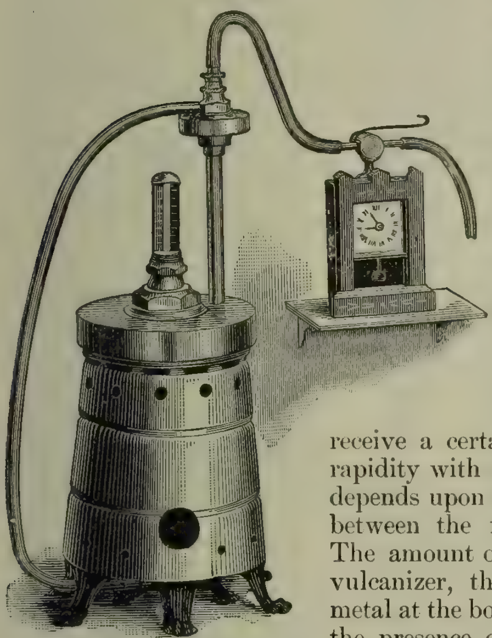
It will be noticed that as the temperature rises the pressure of steam increases in a constantly increasing ratio for equal increments of heat, the pressure being more than doubled by the addition of 50 degrees to the temperature. This fact will show the *absolute necessity* of care and watchfulness while vulcanizing.

When the prescribed time has expired cut off the flame and allow the vulcanizer to cool to 212° F., after which the cooling may be hastened by placing the vulcanizer in cold water, great care being taken not to get a particle of water on the thermometer. When the vulcanizer is cold open it and take out the flask. If this also is found cold, carefully pry the sections apart, and cut away the plaster near the margin of the flask until the centre part containing the denture can be removed.

Fig. 447 represents the Coolidge gas-regulator for dental vulcanizers. This device was invented by Dr. J. B. Coolidge of Boston about the year 1871. It is operated by the pressure of steam upon a thin metal disk, which, yielding to the pressure, closes a valve which controls the flow of gas to the burner under the vulcanizer. The following statement is made in regard to the structure and uses of the apparatus:

"The timing device is operated by the minute-arbor of the clock, instead of the hour-arbor, and is capable of very delicate adjustment as to time, its variation being limited by seconds instead of minutes.

Fig. 447.



Coolidge Gas-Regulator for Dental Vulcanizers.

"The gas-regulator is a better means of maintaining a regular heat than a thermometer, for the reason that as it acts by the steam pressure its movement is positive, and it can be depended upon to act at the desired point after it is once properly set. A certain steam pressure is the result of the application of a certain amount of heat, and it is immediately indicated by the diaphragm of the regulator. Before the thermometer can act it has to receive a certain amount of heat, and the rapidity with which this will be received depends upon the conductivity of the parts between the flame and the thermometer. The amount of air above the water in the vulcanizer, the variation of thickness of metal at the bottom of the mercury cup, and the presence or absence of mercury in the mercury bath, are all conditions which vary and retard the action of the thermometer.

"The following experiment will illustrate the comparative operation of the two devices: Let the vulcanizer be closed with, say, two inches of water in it, and heat applied. The regulator will turn down the gas when the thermometer registers somewhere in the neighborhood of 300°. If the screw-cap of the safety-disk is now loosened and steam allowed to escape for one minute and the screw-cap then tightened, the thermometer will in a few moments be found to register 320°. The reason of this is that as air conducts heat very imperfectly, its mixture with the steam interferes with its conductivity and with the indication of the temperature by the thermometer; but after the air has been allowed to escape there is an atmosphere of steam above the water in the vulcanizer which must be of the temperature due to its pressure throughout its whole extent."

The Finishing Process.—If the model and mould have been coated with liquid silex, the plaster will readily separate from the rubber, which should then be washed with a stiff brush, the case being then ready for the finishing process.

This process is effected with files, chisels, and scrapers made for the purpose; these should be kept sharp. In Figs. 448, 449, and 450 are represented the standard forms of these tools. Fine sandpaper is used

to remove the marks left by the scrapers, and then wet pulverized pumice-stone, used on felt wheels and cones driven by a lathe, will give a smooth surface. This being secured and the case thoroughly washed, the final polish is given by wet precipitated chalk applied by means of rapidly-revolving soft brush wheels. The denture should be washed with soap, and will then be ready for insertion in the mouth.

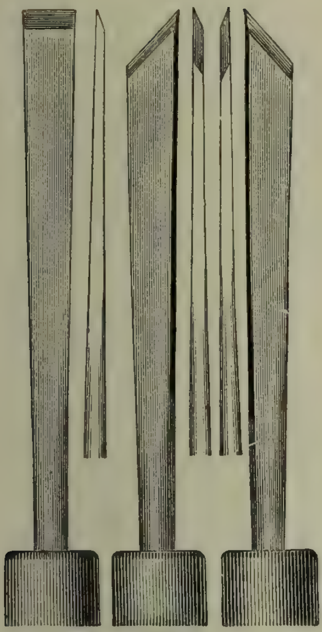
In the construction of a denture where the artificial gum is to be made of pink rubber, "plain" teeth should be used, and the entire plate made of red or black rubber. After vulcanization enough of the rubber surface representing the gum should be removed from around and between the porcelain teeth to allow space for a thin layer of pink rubber. The surface thus exposed should be roughened, trimmed out well between the necks of the teeth, as shown in Fig. 451, and then

Fig. 448.

Scrapers.

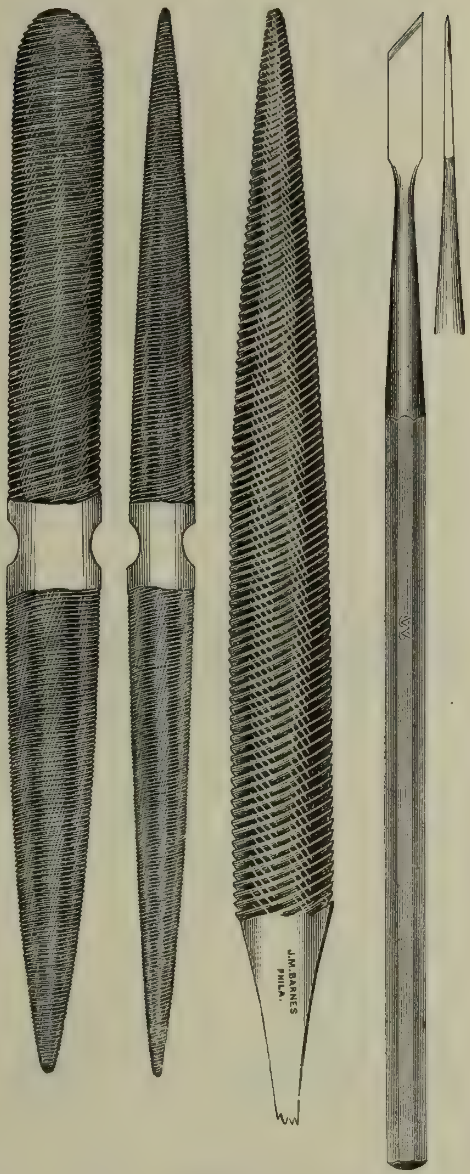
coated with a solution of red rubber dissolved in chloroform. This solution should be about the consistency of thin cream. A strip of pink rubber large enough to cover this whole surface should be softened over boiling water and pressed tightly against the red rubber plate, care being taken to force it well in between the teeth, using a smooth, clean instrument for the purpose. It is not necessary to flask the denture in the usual manner. Wet the plate and place plaster of Paris in the palatal surface; fill the flask with plaster and imbed the denture in it, and place the lid on. When the plaster is hard introduce the bolts, and vulcanize thirty-five minutes at 320° F. When the vulcanizer is cold remove the flask and carefully separate the plaster from the denture. The plate should be trimmed and polished in the usual way. When polished and thoroughly cleaned the pink rubber should be bleached, and thus rendered brighter, by placing the denture in the sun in a covered glass vessel partially filled with

Fig. 449.



Chisels.

Fig. 450.



Files.

alcohol. All trimming should be completed before bleaching, as only the surface of the rubber is changed in color. Fig. 452 shows the finished case.

In partial cases, where an artificial tooth stands alone and the antagonizing tooth comes so near the gum that a thin neck of rubber running from the plate to the tooth would not be strong, select a plate tooth; grind it to fit the plaster model; then fit a gold backing and tongue to the tooth, arranging them on the plaster model to get the proper bend and angle for the metallic tongue. (See Fig. 453.) Cement the two together, invest in sand and plaster, and solder. The portion of the gold plate to be imbedded in the rubber should either have small-headed pins soldered to it or be perforated in several places. Gold clasps can be attached to rubber plates in the same manner, care being taken to so arrange the attachment that it will be thoroughly imbedded when the plate is fin-

ished. In packing the rubber, place a small piece under the metallic tongue, so that when the other rubber is packed and the flask closed the force will not displace the tooth or clasp. Two forms of clasp attachments are shown in Fig. 454.

Preparatory to pouring models for partial cases preparation should be made for strengthening such plaster teeth as stand alone or next to spaces. This is done by placing pins or wires in the depressions made in the impression by the teeth. When an upper model is removed from the impression arrangement should be made to hold the denture in position in the mouth. If atmospheric pressure is to be used, devices to secure suction should be made as for full upper dentures. When clasps are preferred, they can be either of rubber or of gold. The base-plate should be made fully as large as the finished plate is to be, and fitted perfectly to the plaster teeth and model. When there are few teeth to be replaced, a model of the lower teeth will often be all the "bite" and articulation necessary, the facets worn upon occluding surfaces by antagonizing teeth serving as sufficient guides in fitting the casts together before placing them in an articulator; while the plaster teeth on each side of the space to be filled will be a guide for the fulness and length of the artificial tooth.

FIG. 451.

FIG. 452.

Where four or six front teeth are to be replaced, the trial-plate of paraffin and wax is made, and a piece of wax of proper size fastened on it at the point of attachment for the artificial teeth, this being shaped to something approximating their desired length and fulness. The plate thus prepared should be tried in the mouth, and as much care should be exercised in remodelling the features and marking the length and mesial line as in full cases.

FIG. 453.

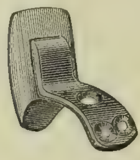
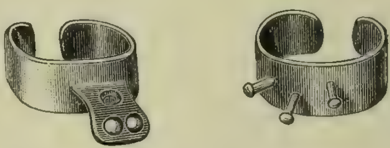


FIG. 454.



An impression of the lower teeth should be taken, and the model from it carefully articulated with the upper cast, and fitted in the depressions in the wax bite made by the lower teeth in the mouth. The two models should then be placed in an articulator, and enough of the wax bite

removed to allow for the placing of the artificial teeth, care being taken to preserve the shape of that portion of the wax representing the gum, so as to have the same fulness reproduced in the rubber. Where the case requires the teeth to rest upon the natural gums the plaster model should be trimmed at the points where the teeth are to set, from a half a line to a line, according to the condition of the gums.

Preparatory to grinding the teeth the plaster model should be wet, so that the cement that is to hold the teeth to the base-plate will not adhere to the model. When fitting the teeth to the plaster model, set them in a little farther, especially at the necks, than they are to be in the mouth; also, leave the incisors and canines a trifle longer than they apparently ought to be, to allow for settling into the gums. Each tooth as ground and fitted to the model should be firmly cemented to the base-plate. When all the teeth are fastened to the plate it should be smoothed and shaped up neatly with a wax spatula. The denture at this point should be tried in the mouth and alterations made, if necessary. After this the plate should be placed on the plaster model and a hot spatula run around the edge to attach it to the plaster on which it rests. When flasking, the teeth that rest upon the plaster model should be held in the lower section of the flask by allowing the plaster investment to pass an eighth of an inch above their cutting edges. (See Fig. 432.) Trim the plaster away from those that rest upon the base-plate, so that they shall be held in the upper section during the packing of the rubber. While the plaster in the lower section is setting, it should be made smooth, and so trimmed as to avoid undercuts. This plaster should be varnished with shellac varnish, and then given a thin coating of oil or sandarac varnish, after which the ring forming the upper section should be placed in position and the plaster poured in, proceeding in the same manner and observing the same precautions as for full cases. When the plaster is hard, place the flask in warm water to soften the wax. Then open the flask carefully. When this is done the wax should be removed with a blunt instrument and the small particles washed out with boiling water. If any of the teeth become displaced, they should be cemented in position with liquid silex; the plaster investment also, if fractured, should be repaired with liquid silex. Save the wax, and, as before described, determine by displacement the quantity of rubber to be used. Give the plaster model and mould a thin uniform coating of liquid silex. The rubber should be packed as before described, except where pink rubber is required in certain parts; this should be packed first, care being taken to use enough for the purpose, and then the other rubber be added. Vulcanize in the same manner as for full cases.

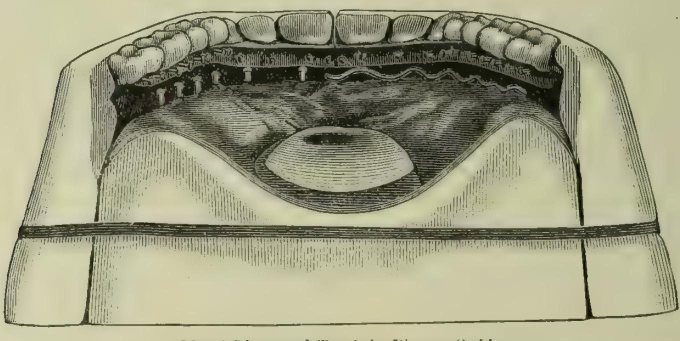
In finishing the rubber should be left to fit neatly around the palatal surfaces of the natural teeth. When fitted to the mouth the plate should fit the teeth perfectly and pass into position easily. If it is desirable to trim the plate away from the palatal surfaces of the natural teeth, the space should, if possible, be made a quarter of an inch wide; otherwise the gum will insinuate itself between the plate and teeth and become extremely tender. If after a plate is finished it is desirable to improve the fit by bending, this can be accomplished by first running a plaster

cast into the plate, and then separating the two and paring off the surface of the cast at the points where the plate is to be bent. Oil the plate to prevent burning, and heat over the flame of a spirit-lamp or Bunsen burner the part to be bent, to soften it, and place it on the cast, and with the hand protected by chamois skin press the portion to be bent firmly against the cast. Hold the two in contact until the plate is cold.

Gold and Silver Plates with Rubber Attachment.

A gold plate having been fitted to the mouth and the bite taken, the teeth are mounted in the same manner as on a wax base-plate. After the teeth are mounted place the plate on a plaster model, upon the outer surface of which several conical depressions should be made. Oil the outside of the model and the labial and buccal surfaces of the teeth, and then run plaster all around outside of the teeth and cast, thus forming a matrix. When the plaster is hard the matrix should be divided with a knife at the mesial line, so that it may be separated from the teeth and model when desired. After removing the wax the position of the pins or loops for the attachment of the rubber can be decided upon and marked. They should be so placed as not to interfere with the adjustment of the teeth, and at the same time be concealed by the rubber. In Fig. 455 the pins and loops respectively are seen in position.

Fig. 455.



Metal Plate and Teeth in Plaster Guide.

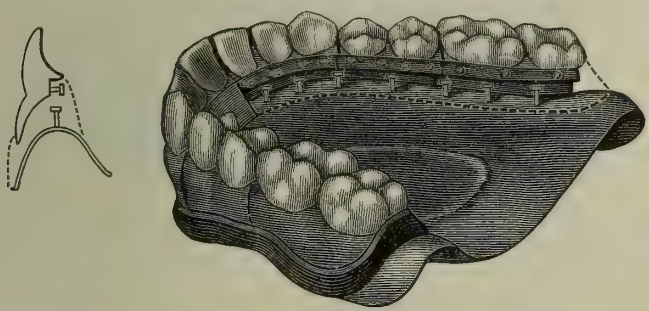
At the points where the plate has been marked for retaining-pins drill holes a trifle smaller than the gold wire, which should be No. 16 standard gauge. Thin the end of the wire, pass it through the plate from the lingual side, and rivet slightly. When the pins are in position solder them to the plate. The pins may be cut short and headed, or left long and bent into loops. An equally strong attachment can be made by using thin platinum wire (No. 19 standard gauge) soldered to the ridge in a series of loops. Loops are preferable to pins, as in the adjustment of the pins there is a tendency to materially alter the fit of the plate and thereby destroy the suction. When the pins or loops are adjusted place the plate on the cast, and by aid of the matrix restore the teeth to position and wax them to the plate, using enough wax to

fill the space between the teeth and the plate and cover the pins or loops, which have been soldered to the latter and the platinum pins of the teeth, using a slight excess of wax to allow for the necessary removal of the hard rubber surface in the finishing process. The surface of the wax should be given the proper contour and be smoothly finished at all points.

In flasking, allow the plaster in the lower section to completely cover the lingual surface of the plate, to prevent the surplus rubber from being forced over it, its presence here being unnecessary, and its removal without marring the plate difficult. Thus flasked, the plate will be held in the lower section and the teeth in the upper. If desired, a gold rim can be soldered to the plate and extended around on the lingual surface where the rubber meets the gold. With silver plate and rubber attachment platinum pins should be used, and soldered to the plate with a low-carat gold solder. The remainder of the process is the same as for gold plate, except that before packing the rubber tin-foil (No. 60) or heavy gold-foil should be placed over the silver plate, allowing the platinum pins to extend through the foil. This will prevent the sulphur from leaving the rubber and acting on the silver, and consequently the rubber will be perfectly vulcanized and the silver plate remain smooth and uninjured.

In Fig. 456 is seen a case fully finished upon one side, the dotted lines upon the other side showing the position the rubber should occupy.

Fig. 456.



The relative positions of the retaining pins in blocks and of those attached to the plate are also well exhibited. Accompanying the cut is a cross-section giving a still clearer view of the relations of the parts.

Fusible Alloy Plates and Rubber Attachment.

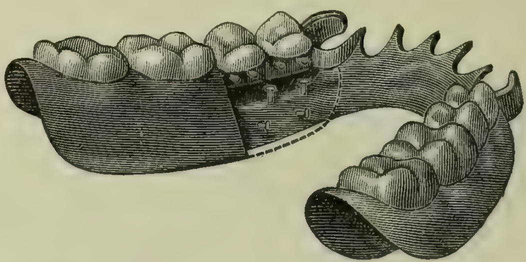
In making a fusible alloy metal plate for rubber attachment the attachment is simply a dovetail groove on top of, and as wide as, the alveolar ridge, and reaching nearly as far back as the rubber is to extend. The teeth are mounted and the case flasked as just described for a gold or silver plate. (For the method of making fusible alloy plates the reader is referred to the paper on that subject in this volume of the work.)

Partial Lower Plates—Combination of Gold and Rubber.

In making lower plates where artificial molars and bicuspids only are required the part of the plate which passes around the lingual surfaces of the incisor and canine teeth may be made of gold plate, and the remaining portion of rubber. Two models should be obtained—one to be used for making metallic dies, and the other for vulcanizing upon. It is preferable to make the gold portion of two thicknesses soldered together. Place the gold plate on the second model. If gold clasps are to be used, fit them to the plaster teeth and solder them to the plate. The ends of the gold plate should extend about three-eighths of an inch back of the canines, and have headed pins soldered to them for the attachment of the rubber. When this is done place the plate on the model and make the posterior portions of the plate, on which the teeth are to be placed, of wax. Care should be taken to hold the gold plate firmly in position while fitting the wax plates. In waxing be careful to cover the attachments. In flasking the gold should be held in the lower section by allowing the investment to pass over it. This will prevent its becoming displaced during the packing of the rubber.

Partial cases that are not sufficiently strong at the points where they pass around natural teeth may be strengthened by imbedding a piece of

Fig. 457.



roughened platinum wire in the rubber. Fig. 457 shows a completed case, with a portion of the rubber removed to show the retaining pins.

Vulcanizing Rubber Dentures in Steatite without Using Wax Plates or Flasks.

In making artificial dentures by this process the usual plaster models are used; these must be given a thin uniform coating of liquid silex. When dry the model should be coated on the surface where the plate is to rest with a thin solution of rubber in chloroform, and then a piece of sheet rubber the proper size and shape should be warmed and pressed close to the model, excluding all air. Any desired thickness may be built up by adding small pieces of warm rubber. The teeth to be used must be heated in a metal tray and one by one be placed in position on the rubber plate. When all the teeth are mounted trim off the extra rubber with a hot spatula and add pieces where needed, and carefully manipulate the rubber with a hot spatula, so as to have it as smooth as possible. Cover the rubber with tin-foil No. 60, taking care not to

alter the position of any of the teeth. The plate is ready for vulcanizing, and is placed in a tin box which should be large enough to allow about three-fourths of an inch room all around for the investment; this consists of steatite or soapstone in powder. The dry powder is pressed in lightly till the box is quite full; the lid is closed and fastened with a piece of wire. The case may then be vulcanized. This can be done in any vulcanizer. When removed from the vulcanizer the tin box can be opened while hot. The steatite will shake out quite dry, and may be used again many times. The plate should be cooled in water. Remove the plaster model and tin-foil from the rubber, and it will be ready for the finishing process, which is done in the usual manner.

Repairing Rubber Work.

Before preparing a plate for repairing it is necessary to have some guide, so that the operation when completed will be satisfactory. This guide is obtained by cementing the old teeth on the plate, or uniting with cement broken pieces of plate if that be fractured, and pouring a plaster cast into the plate, and then, upon the lingual surface of the plate and cutting and grinding edges of the teeth, making a plaster "bite" or articulator. If a single tooth belonging between natural ones becomes broken, it is usually necesssary to have an impression of the space and of the teeth on each side, which impression should be taken with the plate in the mouth. Where a tooth or block is broken and the plate is moderately thick back of the pins, carefully remove them, and enlarge and undercut the holes with an engine burr. In replacing a block sometimes the holes must be united and the groove undercut. After the tooth or block has been ground and fitted fill the holes or groove in the plate with pieces of rubber previously softened, allowing it to protrude slightly. Heat the tooth or block and force it into position, holding until cold. The surplus rubber should be trimmed off or smoothed with a hot spatula. Invest the plate in the flask and vulcanize. When the rubber back of the pins of the tooth is thin, it should be removed and a dovetail made, also a hole through the plate, this being countersunk on the palatal surface. Paint the dovetailed surface with liquid rubber, and then build up with pieces of rubber above the level of the plate and extending forward slightly. Force the rubber through the hole in the plate also, and fill up the countersink. Heat the tooth and force it into position as before described. The surplus rubber should be trimmed and smoothed with a hot spatula. Flask the case and vulcanize. When an upper plate is broken in two, the broken edges should be filed off, so that the new rubber between them will be about one-eighth of an inch wide. About one-fourth of an inch from this edge make with a chisel a clean cut about a half a line deep, extending from the back to the front of the plate. The surface of the rubber between this cut and the edge should be cut away nearly half the thickness of the plate, trimming the edge slightly thinner. A number of holes about half a line in diameter should be cut through this trimmed surface, each being countersunk on the palatal surface. Some of the holes should be made near the edge of the old rubber and some near the edge where the

new rubber is to stop. The object in making a clean cut about half of a line deep the length of the plate is to have the new rubber end in a thick edge which can be polished off flush with the old, and be held in position by it. If the new rubber is run out to a feather edge over the old, the edge is certain to curl upward. Place the broken pieces on the cast and paint the freshened surfaces with liquid rubber. Cut a piece of rubber large enough for the addition and press it well against the plate, being careful that no displacement takes place. After pressing the edges down, place a little liquid rubber on them to keep the plaster out. Invest the plate on the cast in the flask and vulcanize. In cases where the new rubber cannot be placed on with the teeth, it is necessary, after the dovetail and holes have been made, to cement the teeth to the plate with wax, smoothing it with a spatula. Invest the plate in the lower section of the flask, covering all but the lingual surface of the tooth and the wax investment, trimming the plaster so as to avoid undercuts. Varnish and oil the plaster, and flask the upper section. When the plaster is hard separate the sections, wash out the wax with hot water, and replace it with rubber. Press the sections of flask together, introduce the bolts, and vulcanize.

Repairing Rubber Plates with Fusible Metal.

For quick repairing fusible metal can be used. Where a tooth is to be replaced make a dovetail and a hole about one line in diameter countersunk on the palatal surface. When the tooth has been fitted cement it in place on the plate with wax. Pour plaster on the palatal surface of the plate and the labial surfaces of the new tooth and teeth, each side, to hold it in position. Remove the wax, and place several small pieces of the metal in the dovetail. Melt the metal by placing a hot blunt instrument against it. When melted, force it into the dovetail and hole with the thumb, protected with a piece of cloth or chamois skin, and hold it for a few seconds. When cold it can be smoothed and polished the same as rubber.

There are several formulæ for fusible metal. Repairs made by this method are not strong and should not be relied upon as permanent.

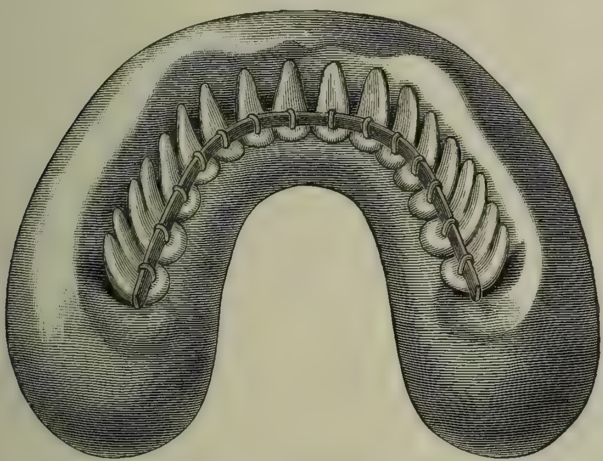
Continuous Gum on Rubber Plates.

A correct impression of the mouth should be taken and a plaster model obtained from it in the usual manner. The articulation should be taken in the same manner as for rubber work, using a paraffin and wax base-plate, and building wax upon the ridge and shaping it to approximate the desired length and contour of the teeth. This should be placed in the mouth and the patient be directed to close the mouth, which must be done in a natural manner; this will bring the lower teeth in contact with the wax and make slight indentations in it. The face should be studied, and the expression of the mouth should be made to harmonize with it in every particular. If the wax holds the lip out too far, it should be removed from the mouth and trimmed off, and then inserted in the mouth again. If the lip falls in, the wax should be built up to restore the proper fulness. It will be

necessary in many cases to carry the wax well up in the position of the canine teeth. In the arrangement of the teeth the cutting edges of the incisors and canines should come a trifle below the margin of the upper lip when in repose. This length, and also the mesial line, should be marked on the wax after the proper expression has been obtained. The wax plate and bite should be placed on the plaster model, and the whole placed in an articulator. A suitable set of continuous-gum teeth should then be selected. Set them up in paraffin and wax upon the model, keeping the roots as long as possible. Shape the wax to the proper contour and fulness, and the denture will be ready for the investment. The investment should consist of plaster of Paris 2 parts, powdered asbestos and powdered fire-clay each 1 part.

Preparatory to investing the teeth the crowns should be painted over with a thin layer of plaster of Paris, which should be allowed to set. Make the investment by mixing the previously-named ingredients with water in sufficient quantity for the case, and place it upon a piece of glass. Imbed the teeth in this mixture, crowns downward, to within half of an inch of the glass. Bring the investment up over the labial surface of the wax and a trifle above its margin. When the plaster has thoroughly set wash out the wax with boiling water. A half-round platinum wire strengthener should be closely fitted to the teeth immediately beneath the pins, the latter being carefully bent over the wire to hold it in position. The wire should be about a line and a half in width. Fig. 458 shows the teeth in the investment, the wax being removed

FIG. 458.



and wire strengthener in position; the pins are bent over ready for soldering. After the wire has been fastened in position the inside of the mould should be slightly oiled. Mix with distilled water a sufficient quantity of Allen's "body" and place it carefully in the part of the mould that is intended to represent the artificial gum, making it as compact as possible and building it up nearly flush with the roots of the teeth, and ending at the upper part of the mould in a thin edge.

If particles of "body" cling to the exposed portions of the teeth or platinum wire, they should be removed with camel's-hair brushes. The pins and platinum wire should be soldered together with pure gold, which can be done while firing the "body" the first time. A solution of borax should be made, and a small quantity placed on the wire and pins where they meet. Wet the gold with borax and place pieces wherever needed. The mould should be dried slowly, which is done by placing it in the mouth of the muffle and gradually introducing it until thoroughly dry. The fire should be in a perfect condition and the work introduced very slowly. When it gets into the full heat of the furnace it should be carefully watched, and when the solder fuses the body will be sufficiently vitrified for the first baking. When fired remove the case carefully, and place it in a muffle to cool slowly. When almost cold it should be placed in hot water to soften the investment and make it part readily from the teeth. Particles of the investment that cling to the teeth should be removed with a clean stiff brush, and then the case should be washed with warm water. On examining the surface of the body cracks will be seen, which should be filled with new "body" mixed with water, and at the same time any additions to improve the contour should be made. The case should be fired again, care being taken to support it on a platinum tray with the teeth downward. After the case is fired a second time, and thoroughly cold, any necessary grinding to make it fit the model should be done. When cleansed the case is ready for the gum enamel. A quantity of Allen's gum enamel should be mixed with distilled water and with suitable spatula and small brushes placed all over the "body" to the thickness of about the third of a line, varying the thickness wherever a deeper color is desired for the more successful imitation of the natural membrane. Any unnecessary water should be removed with bibulous paper, and the enamel should end in decidedly sharp festoons at the necks of the teeth. Place the case, teeth downward, upon the platinum tray and introduce into the muffle very gradually. Test pieces should be placed in during the firing process, and removed at intervals in order to decide when the enamel is sufficiently fused. When the firing is completed and the work perfectly cold, it should be placed on a wax base-plate on the model and the wax built up the desired shape for the vulcanite plate. The flasking and succeeding stages of the work are accomplished in the same manner as for rubber dentures. The rubber will hold fast to the platinum wire and pins and make a perfect attachment.

Fig. 459.

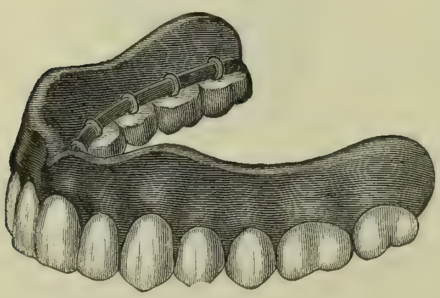
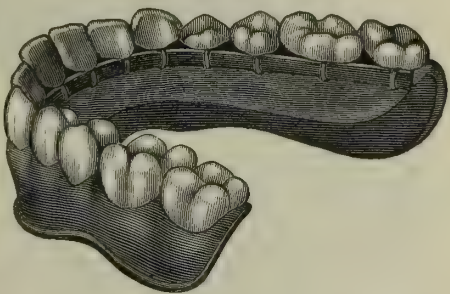


Fig. 459 shows a continuous-gum front ready for the addition of rubber. A continuous-gum front for rubber can be made on a platinum plate in the following manner: Swage up a

platinum plate, about No. 29, three-fourths of an inch wide, to fit the alveolar ridge, and to extend a trifle farther back on the ridge than the position of the teeth. On the labial and buccal surfaces of the ridge the platinum should reach as high as the porcelain is to extend, and be bent and swaged so as to form a rim. The teeth should be ground and cemented to the plate the same as for continuous-gum work. Invest the case in the mixture before described. When the investment is hard, wash out the cement with boiling water, and back the teeth by fitting strips of platinum plate wide enough to reach from the plate to the pins, passing all around back of the teeth, and then bend the pins down to hold the backings in place. The backings should be soldered to the pins and plate with pure gold. When the case is soldered and cold, the investment should be removed and the case boiled in a weak mixture of sulphuric acid and water. The "body" and enamel should be placed on the labial and buccal surfaces, and fired precisely as in continuous-gum work. The platinum, pins, and backings should be free from "body," as they are to be part of the attachment for the rubber and be covered by it. Fig. 460 shows this form of continuous-gum arch ready for the rubber plate.

Fig. 460.



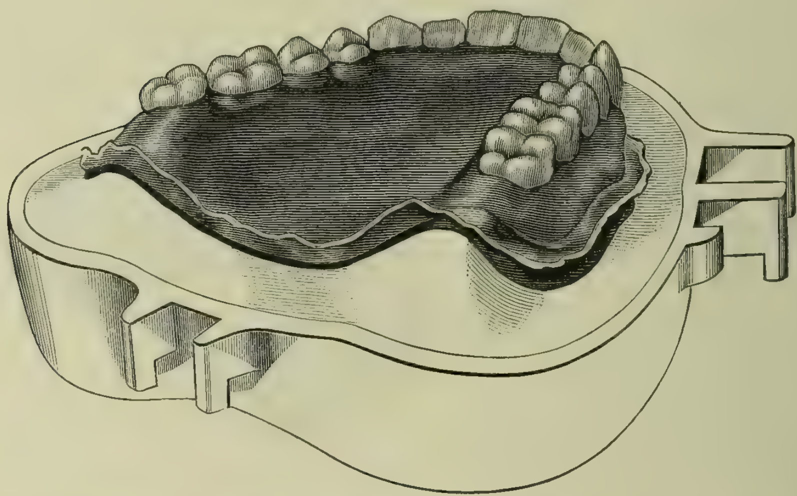
This plate should be placed on the plaster model, and the portion to be made of rubber should be represented in wax. The wax should be fitted to the model carefully, and cover the lingual portion of the platinum plate and extend to the lingual surfaces of the teeth. Care should be observed to keep the platinum plate in close contact with the plaster model, so that the wax will not be interposed and prevent a perfect fit of the plate to the alveolar ridge. Before packing the rubber the lingual surface of the platinum should be painted with rubber dissolved in chloroform, and the remainder of the process will be simply one of manipulating vulcanite.

In regard to these combinations of continuous gum and rubber it may be remarked that as the porcelain gum is usually cracked in many places either after the final firing or after the vulcanization of the rubber plate, and as repair is difficult and expensive, they cannot be recommended as well adapted for general use.

A method of constructing rubber plates by which time and labor are saved in the finishing process is performed in the following manner: When waxing up the plate it should be made perfectly smooth, and as thin as it is designed to make the finished plate. Make a rim of wax about a line in thickness all around the extreme edge of the plate excepting the back. When this is done, burnish heavy tin-foil (No. 60 in thickness) all over the wax, allowing it to extend a trifle beyond the edge of the rim. The tin should be placed on in two pieces—one for

the labial and buccal surfaces, and one for the lingual surface. Bend the edge of the tin-foil up a little all around, so that the investment in the lower section of the flask will not touch it, and then flask it in the lower section. When this is done varnish and oil the plaster, and then bend the edge of the tin-foil out, so that the plaster in the upper section will take hold of it, and finish flasking. Fig. 461 shows a plate in the

Fig. 461.



lower section of the flask with the edge of the tin bent out. When the plaster is hard, place the flask in warm water to soften the wax. Open the flask carefully, and wash the wax out with boiling water. Avoid picking it, for in that process the tin-foil might be disturbed by the instrument. When the wax is out it will be seen that the mould is lined with tin-foil. Surplus grooves should be made in the lower section of the flask. A tin cast can be used if preferable, but a plaster one coated with liquid silex will answer. The rubber should be packed and vulcanized as usual. After the vulcanizing is completed and the flask cold remove the plate carefully. The tin-foil, by virtue of its thickness, will strip off easily, and the finishing required will simply be the edge and back of the plate, which should be shaped as desired and then nicely polished.

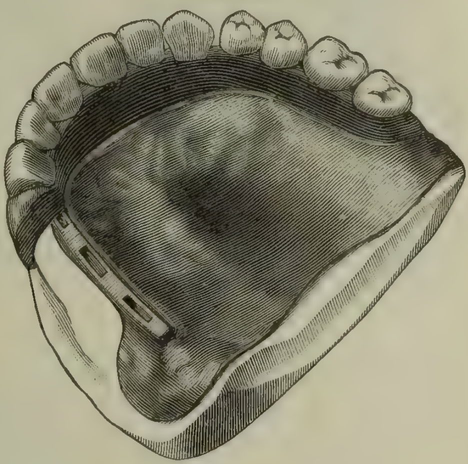
Aluminum Plate with Rubber Attachment.

In making an aluminum plate with rubber attachment a zinc die and lead counter-die should be obtained in the customary manner. The aluminum plate, to be used, should be No. 26 (Brown & Sharp's American standard gauge). As this metal melts at 842° F. (450° C.), great care should be observed in annealing. This is done by thoroughly oiling both sides of the plate, and then heating it until the oil burns, at which time it will be sufficiently hot. Do not attempt to heat to a red

heat. The plate should be fitted to the die, and swaged in a manner similar to that of working gold plate, being more gentle and careful, as the aluminium plate will not stand as rough swaging as gold or silver. By being cautious in annealing and swaging the plate can be conformed to the desired shape with comparative ease. After having satisfactorily fitted the plate to the die and trimmed and smoothed the edges, preparation should be made for the attachment of the rubber. This is accomplished by drilling several rows of holes through the plate on top of the alveolar ridge, and countersinking them on the palatal side of the plate. After the bite and articulation have been taken the mounting of the teeth and the succeeding stages of the work are performed in the same manner as described in the section on Gold Plate and Rubber Attachment.

Another attachment can be made in the following manner: Cut a strip of base-plate wax about one-sixteenth of an inch wide, and fasten it to the plaster cast on the centre of the top of the alveolar ridge, allowing it to extend within one-fourth of an inch of the back of the plate. A zinc die and lead counter-die should be made, and the plate swaged as before described. When swaging is finished, oblong holes about one-fourth of an inch in length should be cut through that portion of the alveolar ridge of the plate which corresponds with the wax strip on the plaster cast, as seen in Fig. 462.

Fig. 462.



Dr. A. H. Forbes of Ithaca, N. Y., contributes the following:

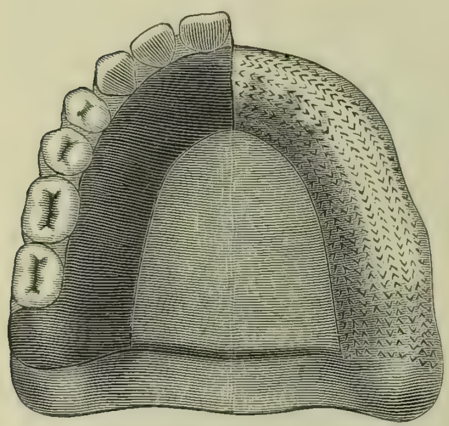
"Over twenty years' experience has proved to me that for full artificial dentures aluminum plates with rubber attachment have no equal. The lightness of aluminum and the fact that it is one of the best-known conductors of heat and electricity are the chief points in its favor. It is unalterable by either dry or moist air, and is affected only by such agents as hydrochloric acid or other chlorine compounds, or by boiling solutions of potassium or sodium hydrate. I have found it perfectly unoxidizable and fully as durable as gold in the mouth.

"For making a full dental plate aluminum should be rolled to about 23 standard gauge. It is absolutely essential that it should be annealed frequently during the swaging process. This can be done safely only by oiling the surface of the plate and passing it over the flame of a spirit-lamp until the oil is burned off and the plate becomes white. The heat must then be instantly withdrawn.

"For the male cast I have used several different compositions, but have never found anything so perfectly satisfactory as pure zinc; for

the counter-die I use soft lead. In forming to the model use a smooth, round-end mallet. When the plate is well adapted to the die, place them in the counter-die and swage with the solid blow of a heavy hammer. Throughout the process *anneal frequently,* and before each annealing be sure and clean both sides of the plate with a pine stick and pumice-stone mixed with water. The object of this is the removal of all adherent particles of lead or zinc.

Fig. 463.



Aluminum plate with rubber attachment. One half the plate represents the spurred surface covering the alveolar ridge and the palatine vault as far as the edge of a broad but shallow vacuum-chamber. On the other half of the plate are seen the teeth with rubber attachment in position.

"When perfectly swaged place the plate upon the zinc die, holding it firmly in position with the fingers, and with a slender-pointed engraving tool 'spur' the surface covering the alveolar ridge as far as it is desired that the rubber attachment shall extend. The spurred surface should be ample, in order to secure a broad surface of adhesion for the rubber, and the 'spurs' or elevations of metal should be sharply defined, well elevated, and thickly placed. (See Fig. 463.) Cover the spurred surface with sheet-wax; take the bite, flask, and vulcanize in the manner usual with rubber attachments to metallic plates. In mixing the plaster for flasking use no salt with the water. Salt will destroy aluminum in a few hours.

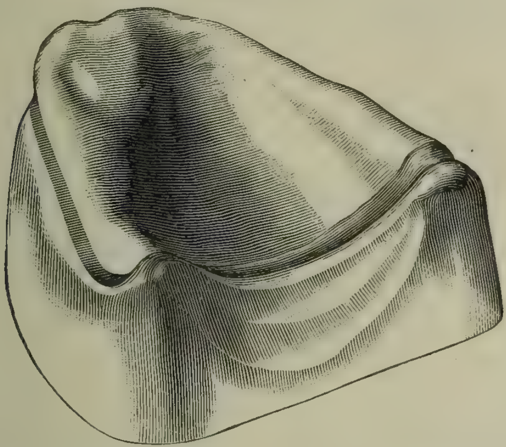
"In finishing use neither sand- nor emery-paper; employ felt wheels with pumice-stone and water. Polish with chalk and water on a fine brush wheel. Aluminum cannot be burnished."

Vulcanite Plate with Flexible Rubber Rim.

In the construction of a vulcanite plate with a flexible rim it is necessary to have the flexible rim closely embrace or clasp the mucous membrane all around the alveolar ridge and press hard against the palate across the back of the plate. This is accomplished by making the outline of the plate on the cast, and then making a groove from near the summit of the alveolar ridge to the plate-line where it forms a ledge about a line in width, as seen in Fig. 464. A strip of flexible rubber which contains but a small percentage of sulphur, prepared for the purpose, about one-fourth of an inch in width, should be cemented in this depression, using as a cement the same flexible rubber dissolved in chloroform. This process is represented in Fig. 465. A wax plate should be made to fit the cast perfectly, and overlap the flexible rubber only about one-eighth of an inch. Care should be observed to have the wax terminate in a clean straight line, and not allow a par-

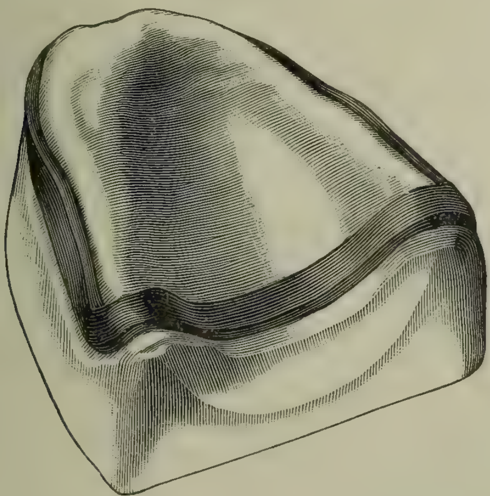
ticle of melted wax to run over on the rubber. The teeth should be mounted on the wax plate precisely as already described for the usual forms of vulcanite work. When the teeth are in their proper

FIG. 464.



positions make such additions of wax as are necessary to produce a finished surface, smoothing with a hot spatula. When flasking the case it is important to have the plaster in the lower section of the flask entirely cover that portion of the flexible rubber that extends beyond

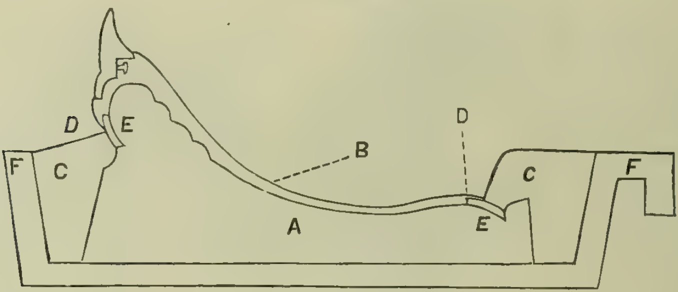
FIG. 465.



the wax. At the back part of the plate the plaster which covers the flexible rim should be about one-fourth of an inch thick. This will prevent the hard rubber of the base-plate from uniting with the soft or flexible rubber of the rim. In Fig. 466 is shown a sectional view of

the denture invested in the lower section of the flask. Letter A represents the plaster model; B, the base-plate; CC, plaster investment; DD, point of union of the flexible rubber rim and the hard rubber plate; EE, flexible rubber rim; and F, the flask. When packing the hard rubber it will form a perfectly strong union with that portion of the flexible rubber that was covered by the edge of the wax plate (letter D, Fig. 466).

FIG. 466.



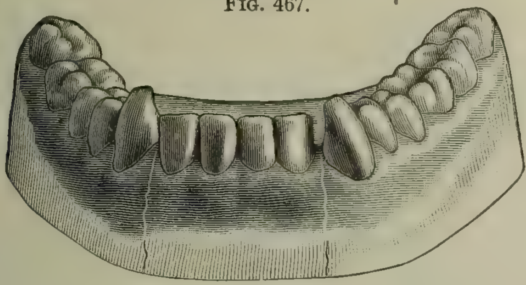
The succeeding stages of the operation are performed in the ordinary way, except that when removing the case from the flask after vulcanizing the lid should be taken off and the plaster separated from the sides of the flask, the plate and plaster being then removed in one piece; then carefully pare the plaster from the plate rather than pry it out of the investment, as in so doing the flexible rim might be materially injured. When the plate has been freed from plaster the hard rubber should be smoothed and polished. The flexible rim will be found to secure a firm adhesion of the plate even in the most difficult cases. As it is made of soft rubber, its durability is limited; but during the time it is worn the patient may acquire the art of keeping the plate in position without its aid.

INTERDENTAL SPLINT.

As it is impossible to keep the fragments of a fractured jaw in perfect apposition while taking an impression, it is necessary to hold them in as nearly correct a position as possible, avoiding of course unnecessary pain to the patient. To ensure success it is necessary to prevent the pieces of jaw from moving when the impression material is being moulded around the teeth and gums. As the mouth cannot usually be opened widely on account of pain or swelling, the impression material should not extend much above the rim of the impression-tray. This does not interfere with success, as the impression of the gums is required only a trifle above the necks of the teeth. Modelling compounds or wax are preferable for taking the impression, as in using plaster of Paris for this purpose the patient would be subjected to a great deal of unnecessary pain in removing it, especially when there are loose teeth. There is also no little danger of their entire displacement when plaster is used. Assuming that the lower jaw is fractured, an impression of the upper is

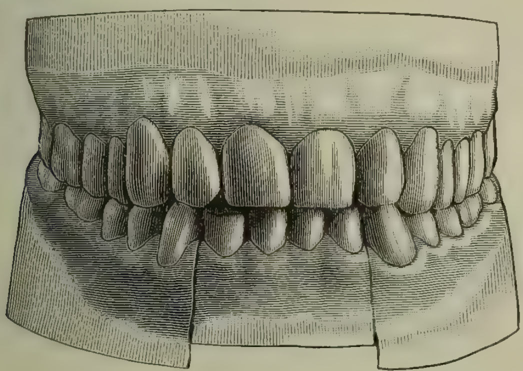
taken in the usual way. When taking the impression of the lower jaw, if the fracture is double, an assistant should stand back of the patient and hold the fragments of the jaw in position with both hands, he being careful to place the index fingers at the points of fracture to aid in securing a perfect joint. If the fracture is single, no assistant is required. Plaster models (Figs. 467 and 468) should be obtained from the impres-

FIG. 467.



sions and carefully articulated. This is done by cutting the lower cast into two or more pieces at the place or places of fracture, and rearranging the sections thus made in such a manner as to allow the teeth of the upper and lower models to antagonize perfectly. This is well shown in Fig. 468. The pieces should be fastened together with plaster, and the two models placed in an articulator (Fig. 469). The spaces between the necks of the teeth should be partially filled with plaster; also any interdental dovetail spaces should have the undercuts filled with plaster, so

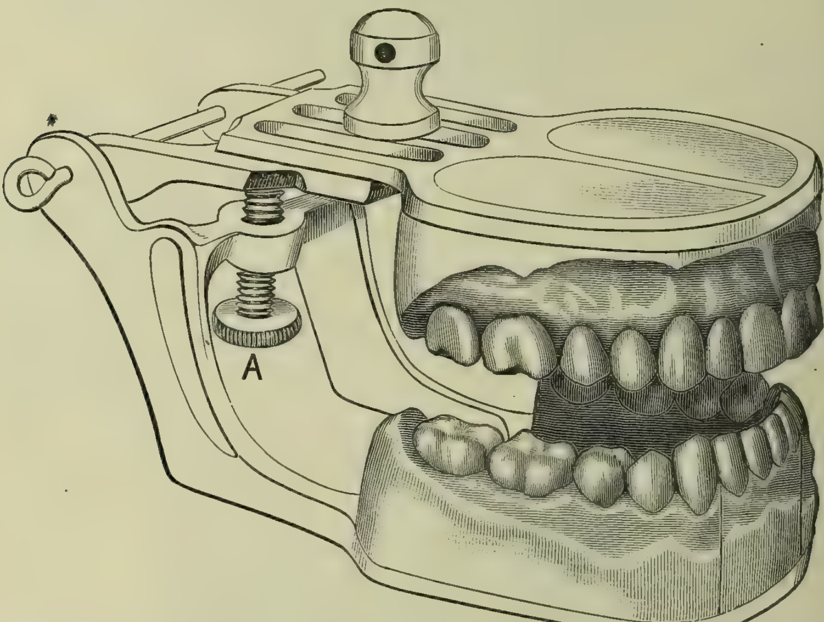
FIG. 468.



that the splint when finished can be placed and removed easily. The space between the upper and lower teeth should be from one-fourth to one-half an inch wide, this being determined by the rigidity of the jaws and the amount of pain the patient would be subjected to on opening them. This being determined, the set screw at the back of the articulator should be so arranged as to preserve this distance (letter A, Fig. 469). Carefully cover every portion of the teeth and gums, about a quarter of an inch above their necks, with tin-foil, thickness No. 60. Over this tin-

foil covering make the splint in wax by placing two layers of thin base-plate wax on the models, allowing it to extend to a point equidistant between the necks of the teeth and the edge of the tin covering. Then make a strip of wax three-sixteenths of an inch thick and wide enough to fit between the pieces of wax on the models, and long enough to extend as far back as they do, joining the three pieces together with melted wax. Pass a hot spatula all around the edge of the wax where it joins the tin-foil to make a perfect joint. The object of the tin-foil is to make the rubber smooth, and to have the splint, when finished, a trifle larger than the natural teeth, so that it will pass in position without binding at any point. The wax splint and tin-foil covering, now being one piece,

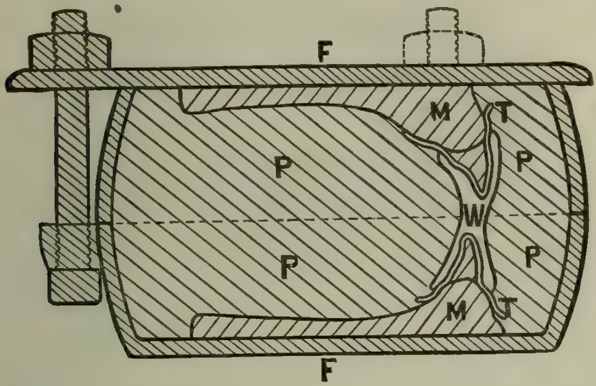
Fig. 469.



should be removed from the models and the models carefully taken from the articulator, trimming their bases and sides if necessary, so that when the splint is in position on them the whole will fit in the vulcanizing flask. A deep flask is required. The lower model with the splint upon it should be flasked first, and the investment allowed to extend halfway up the splint. Trim, varnish, and oil. Place the upper model in position in the splint and finish flasking. By allowing the tin-foil to extend beyond the wax (as at T, Fig. 470) the investment holds it in position when the wax is removed. Fig. 470 gives a sectional view of the flask, etc. F represents the flask; M, the models; P, plaster investment; T, tin-foil coverings of the teeth extending beyond the wax splint; W, wax model of splint. Before opening the flask place it in hot water to soften the wax. Separate the sections carefully. Wash the wax out by pouring boiling water upon it.

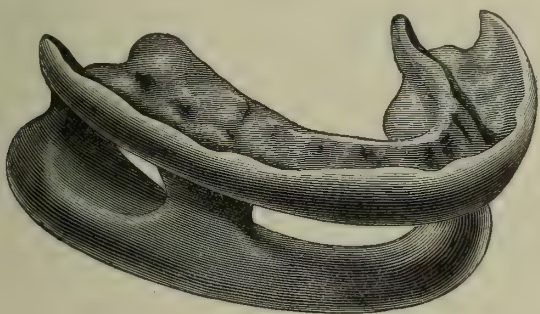
Instruments should not be used to remove the wax, as they might injure the tin-foil. Liberal outlets for the rubber should be made. Cut the rubber into thin strips and soften over boiling water. Pack each section carefully and thoroughly a little more than full. Place the sections together and close them in the usual way. In vulcanizing allow the mercury one hour to rise to 320° F. When this point is reached the temperature should be kept uniform for one hour or more.

FIG. 470.



When the flask is taken from the vulcanizer and has become cold, carefully remove the plaster and tin-foil from the rubber. In trimming, the rubber should be cut away nearly to the necks of the teeth and the edges nicely rounded. The opening made in the splint for feeding purposes should be in front if possible, and large enough to allow for the free passage of a feeding-tube, and should have the edges well rounded. The entire splint should be nicely polished, and no ragged or sharp edges left. Duplicate models should be fitted in the splint to ascertain if it will pass over the natural teeth without binding, so as to require no fitting in the mouth. Fig. 471 represents the completed

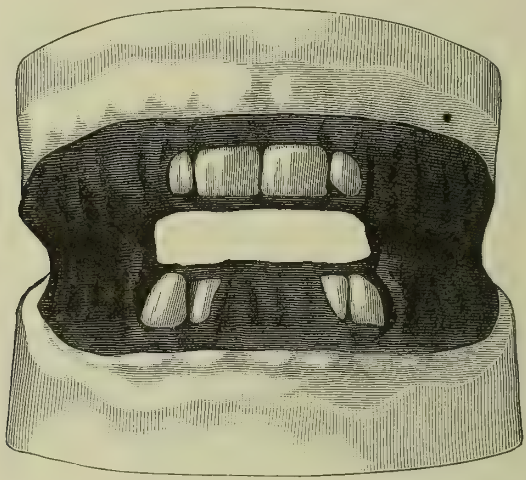
FIG. 471.



splint. It is often advisable to make openings through the top or side of the splint against each tooth adjoining the fracture, so that it can be determined when the fragments are in place. This plan is represented in Fig. 472.

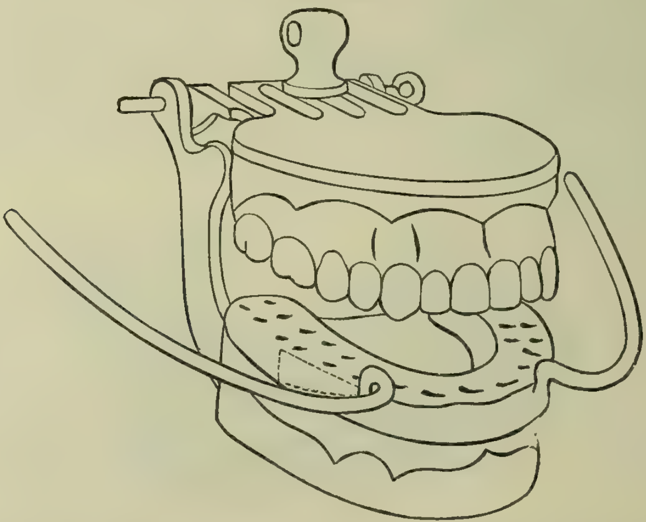
A splint invented by Dr. Norman W. Kingsley consists of a vulcanite covering to the lower teeth, having two steel wires attached extending out of the corners of the mouth and then backward along the cheek

FIG. 472.



on a line with the teeth. It is held in position by having the wires bound to a submental splint of padded wood. The upper teeth must articulate with the upper surface of the rubber, so that the patient can

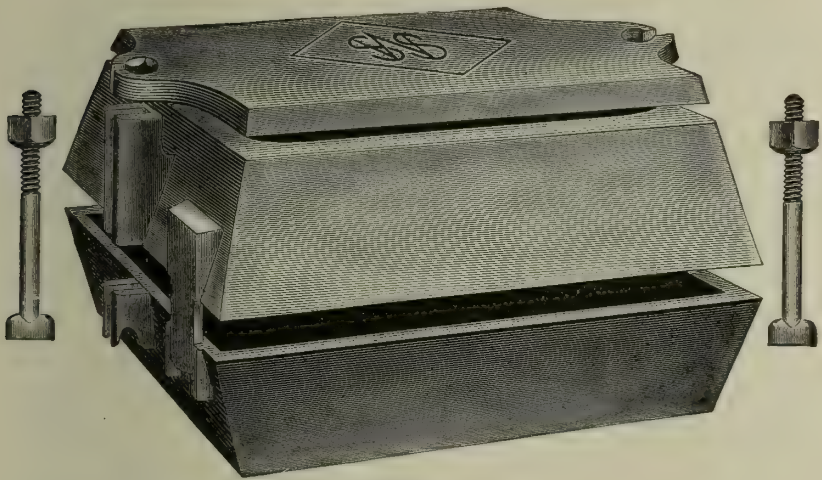
FIG. 473.



use it for mastication. Take upper and lower impressions; pour models and articulate them, as before described, and place them in an articulator. Upon the lower model carefully press a piece of wax about

one line in thickness over the teeth, allowing it to encroach a little upon the gums. Close the articulator to make the imprints of the upper teeth in the wax. The best method to make the arms is to use a couple of old dental excavators. Flatten the ends which are to be imbedded, and curve them carefully, so that they will pass out of the mouth and extend backward without pressing hard on the corners of the mouth, and terminate near the angle of the jaw. The flattened ends should be made quite broad, and be thoroughly imbedded in the splint, as much strain comes upon them. This form of splint is shown in Fig. 473.

Fig. 474.



Box Flask.

Fig. 474 represents a box flask which, on account of its size, is especially useful for flasking interdental splints.

CELLULOID AND ZYLONITE.

By W. W. EVANS, M. D., D. D. S.

Celluloid and Zylonite—a distinction without a difference. Out of these two materials—alike and yet not alike—we have a compound from which are made dental base-plates as well as numerous other articles.

At no distant day it promises to supply many requirements which no other substance now known to the profession is filling. Yet it is but little understood, and in its way there stand many drawbacks.

History.—Pelouze, with a genius for discoveries, found that paper treated with concentrated nitric acid instead of being decomposed retained its form, assuming a parchment-like appearance and flashing into vapor when brought into contact with flame.

Jacobi of St. Petersburg, experimenting with ozone and observing the passivity of iron in concentrated acids, was induced to try the effect of these acids on organic matters. As a result, he patented the discovery of gun-cotton. This was in 1847. Jacobi had simply followed in the footsteps of Pelouze. The second discovery was in no wise greater than the first.

Baron Lenz of Austria brought the gun-cotton discovery of Jacobi into practical use. The Austrian government later on carried it to a more perfect state.

Abel of England also made valuable improvements in the process of manufacture, and sold his patents to Messrs. Prentice, gunpowder manufacturers, for forty thousand pounds sterling—so reported. They, having a large fire in their factories at Waltham-on-Thames, met with sad loss of life from explosions of the gun-cotton, which they were under the impression was not explosive. This was a deathblow to its manufacture for several years. In the mean time nitro-glycerin had made great progress.

Hadon, after a minute examination of cellulose as manufactured for surgical purposes, found that in some hands it was frequently a failure. This led him to the belief that there were several preparations of nitro-cellulose, instead of simply a more or less perfect "gun-cotton." He found that cellulose could be converted into three products by means of nitric acid diffused in sulphuric acid of varying strengths, thus modifying its action. These three products chemists generally designate under the generic name of pyroxylins. They are all nitric ethers of cellulose. They are mononitro-cellulose, dinitro-cellulose, trinitro-cellulose.[1]

[1] The dinitro-cellulose or pyroxylin of the U. S. P. is made by macerating for fifteen hours half a troy-ounce of cotton in a mixture of four troy-ounces of sulphuric acid

The manufacture of the dinitro-cellulose must be a very delicate operation, as the following quotations from some notes furnished me will show: "Temperature of combination, absence of water (hygroscopic) in the paper or cotton, state of division, concentration more or less of the acid—$\frac{1}{2}$ of 1 per cent. of water being capable of producing a totally different product—render the manufacture of the dinitro-cellulose a very nice operation, to that extent that two years ago foremen who manufactured these products for photographic purposes asserted that it seemed impossible to prepare two samples exactly alike.

"On the one hand, dry weather and very concentrated nitric acid render the product hard—*i. e.* insoluble in the test-liquor of 1 part camphor and 20 parts alcohol—and, on the other hand, weakening acids by absorption of water from the atmosphere alone produces zyloidin or mononitro-celluloid, soluble in the acids, and instead of the average 40 per cent. increase, the manufacturer finds an increase of only 18 per cent. and a tendency to rapid change. It takes the process of a very observant operative to remedy these defects, and when without previous correct conceptions of the possible causes of these changes he is very apt to despair."

The extreme tenacity of the film of collodion, it being a colorless transparent material not affected by moisture, suggested its application as a factor in the arts, but the cost of its solvent—namely, 2 parts ether and 1 part alcohol, both lost by evaporation—was prohibitory.

It is said that a gentleman in England named Parkes made the first celluloid in 1855, calling it parksite, zylonite, etc. D. Spill also claims the discovery that a solution of camphor in alcohol dissolved collodion; he took out patents. It was afterward found that wood alcohol was also a solvent.

But the first practical knowledge that we have of the material was in 1869, under the management of Mr. J. Smith Hyatt, who organized the Newark Celluloid Manufacturing Company; this company spent large sums of money in experimenting and perfecting the process of manufacture; they met with accidents and disappointments, and received no

and three and a half troy-ounces of nitric acid, afterwards washing the cotton repeatedly until all free acid is removed, and then drying by means of a water-bath.

The action of nitric acid in the formation of each of the nitro-cellulin compounds is represented in the following equations from Attfield's *Chemistry* (p. 398):

$$\underset{\text{Cellulin.}}{C_6H_{10}O_5} + \underset{\text{Nitric acid.}}{HNO_3} = \underset{\text{Mononitro-cellulin.}}{C_6\left\{\begin{matrix} H_9 \\ NO_2 \end{matrix}\right\}O_5} + \underset{\text{Water.}}{H_2O}.$$

$$\underset{\text{Cellulin.}}{C_6H_{10}O_5} + \underset{\text{Nitric acid.}}{2HNO_3} = \underset{\text{Dinitro-cellulin.}}{C_6\left\{\begin{matrix} H_8 \\ 2NO_2 \end{matrix}\right\}O_5} + \underset{\text{Water.}}{2H_2O}.$$

$$\underset{\text{Cellulin.}}{C_6H_{10}O_5} + \underset{\text{Nitric acid.}}{3HNO_3} = \underset{\text{Trinitro-cellulin.}}{C_6\left\{\begin{matrix} H_7 \\ 3NO_3 \end{matrix}\right\}O_5} + \underset{\text{Water.}}{3H_2O}.$$

As seen in the equations, one, two, and three molecules of peroxide of nitrogen, NO_2, are substituted for one, two, and three atoms of hydrogen respectively, one, two, and three molecules of water being severally formed in the reaction. The purpose of the admixture of sulphuric acid with the nitric acid is to free the latter from the presence of the water formed, sulphuric acid through its affinity for that fluid readily taking it up. Of these three nitro-cellulin compounds, the dinitro-cellulin is the only one soluble in a mixture of alcohol and ether, this solution forming the collodion of commerce.

dividends for seven or eight years, but finally attained a success that resulted in fabulous profits.

The American Zylonite Company, working under Spill's patent, was established about five years ago, and met with some disappointments at the outset from an over-zealousness to use only the most approved processes, but having profited by the experiences of the English zylonite company and the Newark company, it soon overcame its difficulties, and to-day stands at the head for the beauty, uniformity, and strength of the material it produces.

As now manufactured, celluloid is composed of pyroxylin, camphor, oxide of zinc, and vermilion, in the proportions of about 100 parts of pyroxylin, 40 of camphor, of oxide of zinc 2, and of vermilion .06. A very good description of the process of manufacture of the article and of its more important properties will be found in an extract from the *American Artisan*, given in the *Dental Cosmos* for January, 1875, extracts from which I quote below, although I cannot agree with the opinion there expressed that the celluloid is a chemical combination of the constituents named above, so far as dental blanks are concerned, for certain recent experiments with the microscope have led me to believe that it is simply a mechanical admixture. It says:

"After the pulp is ground in the beater-engine, and the camphor and whatever coloring material may be desired are thoroughly incorporated with it, the substance being kept meanwhile at the proper temperature, the superfluous water is removed by pressure and absorption, a peculiar porous material made specially for the latter purpose being employed.

"During the process of drying under pressure and absorption the material becomes nearly converted, so that it is no longer nitro-cellulose, but imperfect celluloid. In so far as conversion has taken place its properties have undergone a total change. All that remains to convert it into the various articles referred to is manipulation under heat and pressure, during which process the chemical combination is completed.

"For some qualities of the material desired to be produced a small percentage of alcohol is added in the subsequent manipulation. As evidence that there is a perfect chemical combination, and not a mere mechanical mixture of the materials, the fact may be stated that whereas camphor in its uncombined state is an extremely volatile substance when exposed to the air, in its combination with nitro-cellulose it loses this property altogether. An enumeration of the properties of the material which we shall give anon will be further proof of the chemical combination. When the material is properly converted comparatively no shrinkage takes place. There is no escape of the camphor unless an excess has been employed, and in that case the excess of camphor will escape from the surface of the celluloid; but whatever uncombined camphor remains in the interior is so closely imprisoned by the solid surfaces that it cannot escape. By varying the proportions of the excess of camphor different degrees of solidity and flexibility are obtained."

The properties of celluloid (the same article goes on to say) are as follows:

"Without the admixture of coloring material it has a pale amber color. If it is desired to make the material white like ivory, oxide of

zinc is used, and for other colors various mineral pigments are incorporated with it, or dyes soluble in alcohol or any of the aniline dyes may be caused to permeate the material to give it any desired color. It is hard and elastic, having a hardness ranging from horn to that of ivory. It is as tough as whalebone. In elasticity it greatly exceeds ivory. . . . .

"Celluloid is also a very fair non-conductor of heat and electricity—not quite as much so as hard rubber, but approximating the latter very closely in this particular. . . . . While it is so good a non-conductor, it is not perceptibly electric. . . . .

"But perhaps the most remarkable property of this otherwise very remarkable material is the fact that it becomes plastic at a temperature of from 250° to 300°, and this property enables it to be moulded with facility into a great variety of forms for ornament and utility. Pure celluloid has a specific gravity of about 1.4.

"A profitable and successful industry based upon these properties of celluloid is the manufacture of dental plates. The material can be made precisely the natural color of the palate and gums. It is much stronger than rubber, and has a perfectly clean surface. It may be manipulated more easily than rubber, as it does not require to be vulcanized. It possesses all the valuable qualities of rubber for dental purposes without its defects. It requires only about one-sixtieth as much vermilion to give the proper color to celluloid as is required to impart the usual color to rubber. The danger of salivation which sometimes occurs in the use of rubber for dental purposes is therefore obviated. The difficulties encountered in the application of celluloid to dental plates have been very great, and many failures were at first experienced, but with untiring perseverance the inventors have pursued the subject until during the last year or two they claim to have produced an article possessing all the requirements desired, not a single failure having been experienced through any fault of the material made within a twelvemonth past."

The first process for moulding celluloid into dental plates was that known as the oil-bath. In this the oil was placed in a small cast-iron box or tank containing the flask, and the whole was heated to the boiling-point, the flask being closed by means of a clamp.

Next we had the glycerin process. This certainly was an improvement, for if a good quality of the material was employed and perfect cleanliness preserved, there was no unpleasant smell, and the glycerin was not liable to become rancid, and, being readily soluble in water, the flask could be kept free from dirt. This process is still used by many dentists, the machines, etc. employed in it having been much improved.

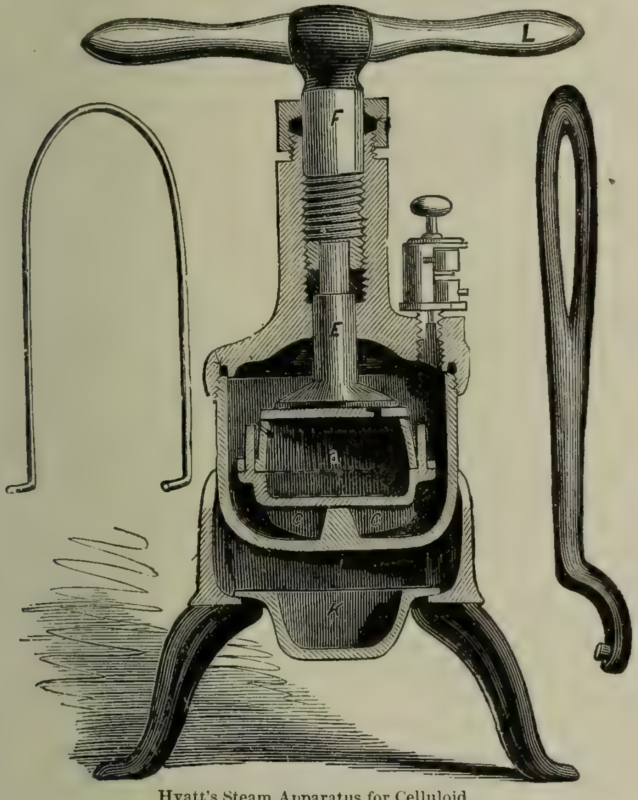
The two remaining methods of moulding this material are by steam and by dry heat,

Dr. I. H. Alexander claims the lead in the employment of steam to soften celluloid,[1] and as I find no denial of his claim and no previous assertion of right to the position, we will let him hold the first place until some one else shows a better title. Since I have myself had very

[1] *Dental Cosmos*, May, 1875, p. 280.

little experience in the use of the steam apparatus, I will copy from the little pamphlet of instructions issued by Messrs. Hyatt & Co., the celluloid manufacturers of Newark, N. J., the accompanying design representing their latest improved steam apparatus, together with the following description of its management (Fig. 475):

FIG. 475.



Hyatt's Steam Apparatus for Celluloid.

"Fill the boiler partly full of water. The amount is not material, but there should always be enough to cover the ribs at the bottom. Have the screw well turned back, until the plunger when in position will rest against the top of the boiler, otherwise the flask may be pressed upon while screwing down the cover and the cast injured. Turn down the cover snugly; see that the gland is turned back and the screw works freely. Many failures have occurred by neglecting this simple matter. If it works hard, it is impossible to tell how much or how little pressure is being exerted; there may be too much, and blocks or cast may be broken, or too little, and the plate made porous. In all methods of working celluloid, the sense of feeling is the best guide as to when and how hard to turn, but in order to have this there must be perfect freedom of motion of the parts. The time elapsing before turning is not reliable, as it varies with the heat employed, the temperature at starting,

the amount of water in the boiler, the drafts of air to which the flame may be subjected, etc.

"After placing the flask in position turn down the screw very gently with thumb and finger until you feel it touch the flask. Fill the cup with alcohol, and light it or light the gas. The safety-valve is made in two parts. The upper portion may be suspended by the pins in the lead weight; the valve will now blow off steam (if in proper order) at a temperature of 225°. Until this occurs no particular attention is necessary, but from that time the exclusive attention of the operator should be given to the moulding. Many failures occur from the want of this, for the plate may be easily injured from too much heat without proper pressure. But fifteen or twenty minutes, at the most, will be required from this point, with proper heat, and nothing else should be attended to.

"At the point when the steam escapes from the valve with the upper portion suspended the plate will soften, and the screw will be felt to yield to light pressure with thumb and finger. The upper weight should now be dropped down. Turn the screw very carefully, stopping when you feel the resistance increase; as soon as it yields again turn it more, going slowly and carefully at first, but increasing the pressure somewhat as the steam gets up, which you will know by occasionally raising the valve. It is just here that judgment is required to avoid, on the one hand, too much pressure before the material is sufficiently softened, which would result in fracture of the cast or blocks, disarranging the articulation, or a 'flaky' plate, and, on the other, too little pressure after the heat is up, which would result in injuring the quality of the material. The pressure should be followed up as the heat rises and the screw yields, the object being to get the whole of the plate under pressure in every part of the mould by the time the steam blows off quite sharply and steadily on raising the safety-valve. After this the pressure should be increased, but time should always be given between the turns for the slowly-flowing celluloid to escape from under the pressure. Toward the close of the process the pressure should be considerable—in fact, about all that can be applied with the machine—and should be continued as long as the screw can be turned. If the operation has been properly timed, the steam will blow off at the safety-valve at about the time the moulding is completed and the alcohol in the cup is consumed. If it should blow off before that, no harm would be done, as the heat cannot become too great if the safety-valve is kept in proper condition. The remarks apply to the use of alcohol in the cup furnished with the machine. If any other heat is used, the flame should be sufficient to complete the process within thirty or forty minutes. If more than this is consumed in the moulding, the quality of the plate is injured."

I have given the above description in full for many reasons. The general description of care and attention is applicable to all machines. The effects from carelessness on the part of the manipulator will explain some points connected with the material that will appear farther on.

We now come to the dry-heat process, the one which, in my own opinion, will give the best and most satisfactory results, the proof of the correctness of which opinion I hope to give in a practical way as we progress.

The credit of having originated this method belongs, I believe, to Dr. R. Findley Hunt of Washington, D. C., though I understand that other gentlemen set up claims to the discovery. Whoever may have first conceived the idea of this process, however, it is certain that Dr. Hunt produced the first practical manifestation of it, and his were the first machines known to the public. As there are so many dry-heat machines now in the market, attention will be centred at once upon the class which experience leads me to believe is the best—those that have a dry oven surrounded by steam. I prefer machines so constituted, for two reasons: First, you cannot with them readily burn your plate, as in the intense dry-air heat apparatus; and secondly, you can consequently with safety carry the temperature to a much higher degree, and so get a more perfect fusion of your material.

Of these the two most desirable are the "New Mode" heater by Dr. J. S. Campbell, and one patented by myself. The former of these is well known, and modesty would deter me from pressing the claims of the other, so I shall pass over any further description.

Before proceeding to describe my method of working celluloid, perhaps it would be well to give some further reasons why I consider this peculiar dry heat produced by steam superior to either a steam-bath or direct dry heat.

Celluloid is peculiar. To be properly managed it must be understood. It must be studied, manipulated carefully, and controlled, for it has a character of its own. The Celluloid Company claims that it is a "complete chemical composition." The article copied from the *American Artisan* adopts the same view. From this view I dissent, as some recent experiments with Professor Tarr of the Georgetown University lead me to believe that it is merely a mechanical admixture, the microscope showing very clearly the two most important constituents, camphor and gun-cotton, in their natural state, which could not be if the substance were a chemical compound. In these experiments thin specimens of pure celluloid before treatment and after being put into the vulcanizer were examined under a microscope having a power of three hundred diameters, and the view by transmitted light revealed a structure irregular and grooved, with flinty appearance and protuberance of black specks. Stray threads of nitro-celluloid were noticed in some cases corresponding with the grooves. In one instance, the specimen having been disturbed, a fibre was displaced and the underlying groove distinctly seen. The same specimen, by reflected light displayed a clear, crystal-like surface, similar in appearance to a heap of small bits of camphor, and the black specks noticed before were very like protruding shreds of cotton. This would seem to indicate that the pyroxylin and camphor had not united chemically, but were merely mechanically mixed, and by means of the great pressure exerted upon them formed into a solid mass. In order, however, to make assurance doubly sure, pieces of pure gun-cotton were examined under the same glass, and no distinction could be observed between them and those discovered in the celluloid. A thin, transparent wafer of camphor also was examined, and the appearance was exactly the same as that of the main body of the celluloid, without the black specks.

Before going farther into this portion of the subject, I will give my own method of working celluloid and zylonite, and afterward try to explain causes and effects of successes and failures, and the relative value of celluloid and zylonite.

Fig. 476.

Set of Carvers.

In the first place, a good impression is indispensable. For taking impressions I prefer plaster in all cases, and I think it ought by all means to be used where partial impressions are desired. Next, spare no time or trouble in getting an accurate occlusion for the articulation. These are the foundation-stones of success. And I digress for a moment here to say that while I am thoroughly progressive, I am nevertheless decidedly opposed to fanciful articulators. I cannot believe that if an articulation is not right in the first place any mechanical device of screws, bolts, and triangles can make it so. We should be able, when our piece or pieces are polished, to send them a thousand miles from home with the knowledge that they will not require the slightest grinding or change in occlusion, and that they will not bruise or inflame the soft parts of the mouth. This is skill, but it is very easily accomplished with a little care. Having procured this solid foundation, next make upon the model a wax plate of the same thickness as that which we desire our denture to be, or a little thinner than that. I am very particular about this, and prefer the pink paraffin and wax found for the purpose in the dental dépôts in the form of thin sheets and in sticks. The reasons for using this wax rather than others are obvious: it is cleanly, does not soil or stick to the hands or teeth, is dry and carves nicely, and, as it is nearly the color of the gums, it serves as a convenient guide for carving. In an upper plate I use only one thickness of the wax over the palatal portion, since I do not find it necessary to try in any preparatory plate. Warm the wax and press it gently over the model, throwing out in relief any rugæ, etc. that may exist. Select the plain teeth made for celluloid, as they are probably the most natural in

shape and shade of any now in the market and allow of a finer display of skill and taste than any others. The grinding and arrangement of the teeth are regulated by the individual case in hand and the artistic ability of the dentist.

This also is a separate study, and could scarcely be treated under this head without injustice to the subject, so we will pass to the next step, the carving. It is a very simple performance if we have only studied a little from nature—taken a few impressions of the natural gums and teeth in health and in disease, irregular and regular, with spaces from lost teeth, and so on. With models of this kind before us, and a remembrance of the face of which we intend to restore the features, the case is not a difficult one. I use in my own carving three little double-end tools, represented in Fig. 476, the uses of each of the points of which I will now explain. Fig. 477 presents a full set of teeth in pro-

Fig. 477.

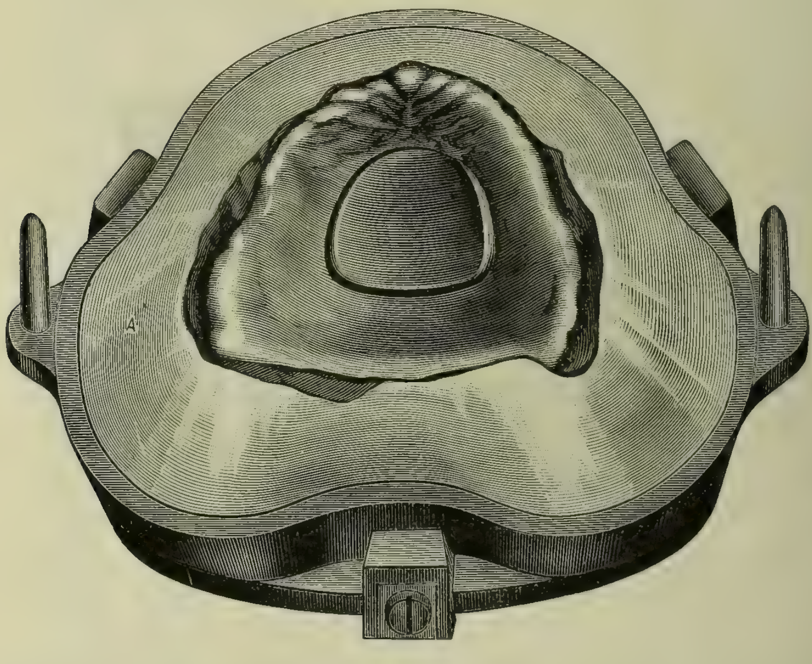
cess of carving, the upper half, shown by B, having on it the rough wax as dropped there carelessly while grinding and adjusting the teeth, the lower denture, at C, showing where the wax has been cut away from the teeth in scallops by the straight-bladed knife of carver No. 2, and roughly shaped up with the spoon end of the same instrument. Next is used the smaller spoon end of No. 1 to form the fossæ or depressions lying between the roots, and the curved knife-blade of the same to go around the teeth on the palatal side.

Having carved the wax in this way, forming festoons or exposing roots as the case may require, take a spirit-lamp with a small flame and an air-bulb (which is better than a blowpipe), and by gently puffing upon the wax smooth away the rough, irregular projections while retaining the larger undulations of the form desired. We are now ready for the tin-foil and stippling. Take a strip of No. 60 tin-foil a little wider than the outside surface of the gum, and by commencing at one side with the broad end of the ivory-pointed carver No. 3 burnish the tin down smoothly and uniformly over the entire surface, occasionally using

the pointed end to work between the teeth and the straight blade of carver No. 1 to cut the tin from around the teeth. The inside of the model is treated in the same way, except that a narrow V-shaped piece is cut from the tin before placing it on the palatal surface, to avoid folding, and that the entire outer edge of the plate is trimmed around. The stippling is done with an ordinary blunt-pointed excavator or with a suitable engine-plugger that will give a reacting blow. If done delicately and closely, the effect of the stippling is very pleasing.

The investing of the piece in the flask seems simple enough, and yet a few suggestions may be of benefit. Always mount the model high in the shallow half of the flask (see Fig. 478), for reasons hereafter ex-

FIG. 478.



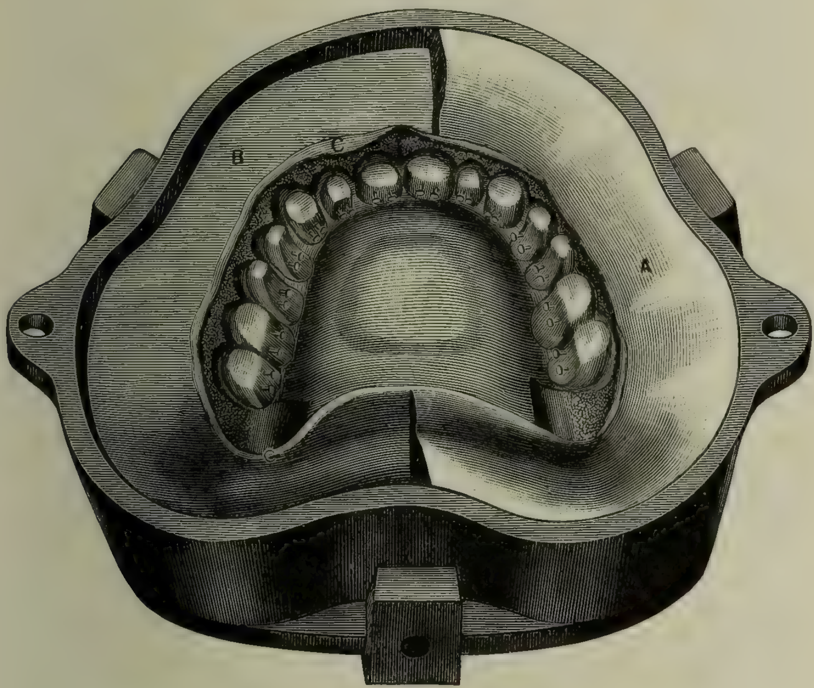
plained. Pour the plaster—neither too thick nor too thin, but of about the consistence of syrup—until it reaches the lower edge of the plate, no higher. When sufficiently hard, trim and use liquid soap as a separating material, as varnish is more or less dirty and will soil the work. Place on the deep ring and pour in the plaster, taking care to have no air-bubbles. Then with a little stick (ordinary wooden toothpicks are good—better for this than for the purpose for which they are made) stir gently to and fro around the outside of the teeth to work the plaster into every little crevice between them. Put on the top, wash the outside of the flask clean of the surplus plaster that squeezes out, and place it under gentle pressure until set—say, for half an hour or more.

If there are any undercuts, put the flask into hot water a few moments before separating it, so as to soften the wax and prevent breakage. Hav-

ing separated the flask, pour, from a pitcher or other convenient vessel with a spout, boiling water on the wax until all is washed out, taking care not to disturb the tin-foil.

There are several ways of cutting vents for surplus material, but I prefer the one illustrated in Fig. 479, the upper half of flask as shown

FIG. 479.



in Fig. 478 of a piece invested. The wax has been washed out, exposing to view the roots of the teeth, platinum pins, etc., as ready to receive the base-plate, the stippled tin-foil as clinging to the sides of the plaster, and the reverse or female matrix A from the elevated portion A on the male half of flask, Fig. 478. B indicates a portion of A cut away, illustrating the manner of forming vents; in this cut it is only carried half around, so as to show before and after preparing. I commence by cutting a deep groove all around the piece close to the flask and gradually tapering up to the tin-foil or the margin of the plate, marked C. By this arrangement the material has free exit all around, yet may not come out too rapidly. The plaster margins are not likely to be broken away under pressure, as the vent runs out almost at a right angle, thus leaving solid walls. Another advantage in this style of vent is that after the two halves of the flask have been pressed home the surplus material parts readily from the piece, leaving very little to dress up.

We now come to the process of baking, the manner of conducting which by the steam method has been already described. To bake by dry heat takes perhaps a little longer than by other means, on account

of the necessity of expelling the surplus moisture from the plaster in the flask. Place the flask in the dry oven, having first slipped two small spools over the guide-pins to keep the halves apart, and close up all the openings to the oven except the small valve communicating with the outer air from the dry chamber, as this must be left to carry off the steam generated from the moisture in the plaster. Then raise the steam in the boiler to 320°, and keep it there. This will give a temperature of about 300° in the dry chamber. Let the flask dry out for not more than an hour, and then when touched with a wet finger, as the laundress does her smoothing-iron, the same "sizzle" will be produced. The case is now ready for the celluloid blank, which must first be trimmed to the proper size, trying always to have a slight excess, but being careful not to have too much, since I think it a mistake to use a very great amount of pressure at any stage of the process. Replacing the flask containing the blank in the oven, leave it there from ten to fifteen minutes to soften; then try closing by turning the bolts for that purpose. In this be very careful; be sure that the bolts work easily and are true. The sensation of touch upon the wrench is the surest index of the amount of pressure that is being employed; and this, in the beginning, should not be more than can be exerted with the thumb and finger. The operator can raise the lid and see if the blank is soft by touching it with an instrument. As soon as the material has become soft enough, close the flask immediately, occasionally resting a moment between the turns, however, to give the zylonite time to spread. The operation of closing the flask usually occupies from five to twenty minutes. When it is closed tightly —and you should not stop until it is tight if you wish to retain a perfect articulation of the teeth—it is better to leave the case a few minutes under heat to season, when it may be taken out if in a lock-flask in the "New Mode" vulcanizer; or if in my own, raise the top, which in reality forms a clamp or press, and set it out of the window or in some other cool place to temper down. If a lock-flask has been used, so much additional time can be gained, but never cool the flask suddenly in practical work, and never allow it to be freed from pressure from the moment it is closed until perfectly cold: one causes warpage; the other, shrinkage from the teeth.

Care should be exercised in removing the piece from the flask, on account of the hardness of the plaster when subjected to the dry-heat process. Having taken off the top and bottom, lay the flask in water for a few minutes. Then press a knife-blade between the two rings, and a gentle movement will cause one or the other to leave the plaster, when the remaining one is easily detached by a few blows of a hammer on its wide edge: knowing the position of the teeth, it is now an easy matter to get the piece out whole. Wash off whatever plaster may adhere to it, trim away the surplus, remove the tin-foil, and finally, having scraped and smoothed the edges with felt and pumice-stone, put a high polish over the entire surface with brush-wheels, pumice, and chalk, taking care not to use too much friction.

Repairing this material is not so difficult as many seem to think, the process being very similar to that employed in mending rubber. If the

plate is comparatively new, having been lately made, there is no special need of a great deal of "dovetailing," as the material with its solvent will readily unite. If, however, the piece to be mended is old, I scrape away the edges of the fracture, dovetail and drill two or three holes through the plate, reaming them on the inner surface in order to clinch the material when it goes through. Then wax these holes smooth on the inner surface with paraffin and wax; restore the outer surface with the same material to the original shape, and with the new teeth, if any, in place, invest in a flask, covering all except the parts to be repaired. After separating the flask wash out the wax with boiling water, and moisten the portions previously covered with it with spirits of camphor or the liquid zylonite or celluloid made of one part zylonite scraps in three parts spirit of camphor. Then, preparing a piece of new blank a trifle larger than is actually needed, soak it in the camphor mixture until it becomes sticky, place it in position between the two halves of a flask, and heat the whole in the oven as directed, twenty minutes or half an hour, and screw home. If steam be used, but a few minutes need be allowed to soften the celluloid, and then the flask may be immediately closed. By pursuing this course, taking care to have everything clean, absolute mechanical union will be obtained, unless the piece is quite old or has been baked by one of the liquid processes or by steam, and has become saturated. It sometimes happens that through a desire to be too exact not quite enough material may be used, a pin or two may be left partly exposed, a slight corner left out, or some other little defect of a like sort caused—not enough to interfere with the fit or to loosen a tooth, but enough to annoy the critical eye of one who takes pride in symmetry and a nice finish. To correct these slight blemishes use zylonite filings moistened in spirits of camphor, and press gently into the inequalities with a heated burnisher—not too hot, by the way. Allow such pieces to stand a while before the final polishing and finishing. Another convenient way to put in a tooth in a hurry is to cut out the broken portions, dovetail, grind in the tooth, and unite to the plate with amalgam.

I shall proceed now to answer more or less at random a few of the more important of the questions that have been asked me concerning this subject.

First, it has been inquired what kind of plaster I use for my models and how I get them so hard. I answer: Simply, the ordinary best Newburg plaster employed by the plasterers in house-decorations, such as cornices, etc. It is strong, sufficiently fine and smooth, and if properly manipulated will make very hard models, the hardness of which is increased if when they are dry and absorptive they are dipped into a boiling solution of borax or into a solution of one part of silex in five of water.

Again, I am asked how it is that my models are always so smooth and free from air-bubbles, nicks, bruises, etc. The reason is simply that I try always to bear in mind that my model represents the mouth exactly, or should do so, and that any blemish upon its surface must necessarily be transferred to the plate, and will afterward irritate the mucous membrane, if not materially affect the fit of the piece. This

is a matter about which most dentists are, I must say, usually very careless.

I would suggest also that if vacuum-chambers are used they should be carved from the impressions before pouring. It might perhaps be well, too, to answer here the question whether tin models should always be used. I should say, Yes, except where it is extremely inconvenient to do so; and for several reasons: First, a tin model under pressure with teeth and undercuts is not likely to break; second, the microscope reveals the fact that the surface of the celluloid is made more dense in structure where it comes in contact with tin or tin-foil than where simply pressed on plaster; third, tin-foil cannot be placed on the model without materially affecting the accuracy of the fit; and fourth, a model of the case can always be retained. A tin model—or a tin shell of a model, which is even better, because there is no perceptible shrinkage; it is lighter and it takes less material—can be made in less than ten minutes if all the requisites are convenient and how to do it is known.

There is an impression, it would seem, that I use celluloid or zylonite to the exclusion of all other materials in making plates, but such is not the case, for I employ gold, platinum, and continuous gum even more frequently than zylonite. No one of these substances will suit the idiosyncrasies and pockets of all patients. Most men like to ride hobbies; so dentists are frequently found claiming for their own favorite among these materials capabilities to answer every possible requirement. Pamphlets have been written professing to prove the pernicious effects of rubber and of celluloid, the poisonous tendencies of vermilion, the destructive results upon the mouth of vegetable bases as non-conducting agents, but showing, in reality, only the ignorance of their authors of the whole subject.

There are many reasons why I like celluloid. It is cleanly, beautiful in appearance, and allows of any amount of artistic skill in the use of single teeth to restore Nature's sad losses of which no other material will admit. Then, it has other advantages over most of the substances in use. Take rubber, for instance. Rubber is a valuable base, even if it is unjustly accused of poisoning and all sorts of dreadful things, but it has serious drawbacks, in its color principally, which necessitate more or less the using of gum teeth.

Next, take continuous gum: its greatest objection is its weight, which many patients will not submit to, even although they might well afford to pay for it; but in addition to this there are few dentists who can produce a really natural gum-color, to say nothing of expression. Gold, too, is not without its weak points; for example, unless united to the teeth by some plastic material it will always leave numerous crevices between the teeth, plate, and backing. But gold, platinum, and aluminum plates in connection with zylonite make very substantial and beautiful pieces.

One of the charges against celluloid is that it is not stable enough. I think this is a slander; at least it is so with the preparation under the name of zylonite; for by comparing its durability with that of other substances I have reached the following conclusions: The mean dura-

bility of vulcanite plates is over-estimated. A fair average of their life is very probably not more than six years. Of course, many last longer; I know of some that have been worn twenty years. But these are the exceptions, and many do not last a single year. Continuous gum, except as manipulated by a few careful hands, is continually breaking, and becomes decidedly expensive and annoying. Celluloid has been in existence, for dental plates at least, only about ten or twelve years, and yet I am told of many plates of this material that have been worn with satisfaction for eight or nine years, and this with all the disadvantages of a new compound.

The warping of plates may be caused in several ways. If the material is pressed home under high pressure and at a low temperature, the plate, having yielded to the pressure, necessarily tends to revert to its original shape by reason of its great elasticity, no radical displacement of the molecules having taken place. And if the flask is removed from under pressure before it is thoroughly cold, there is again a tendency to warp. Heating the plate with friction in polishing will also cause this evil, as also with rubber. If these causes can be avoided there is no need that a plate should warp.

These accidents are simply the result of carelessness—one of the attendants, usually, of too cheap dentistry—but the first needs something more than care to remove it. It can only be obviated by the use of that class of machines which allow of carrying the temperature high enough to make the material thoroughly plastic, so that it will yield readily to light pressure. In this state the cohesive force of the molecules of the body being reduced to a very small quantity, they will evince no tendency to return to their former position after a displacement, and a change may be produced in their relative positions which will become permanent when the cooling of the plate allows the force mentioned to again exert its influence. But it is claimed by the advocates of steam machines that this high temperature of 280° and upward is very injurious to the plates, and also that "too little pressure after the heat is up" will cause the same result—the puffing up, that is, of the material and its filling with air-cells, etc. These assertions I believe to be true when applied to the process of moulding with steam, but I know them to be false when applied to the process which uses the peculiar heated air which comes in contact with the celluloid or zylonite in the machines having a dry chamber to bake in surrounded by steam.

I think I can suggest an explanation, but I wish it distinctly borne in mind when I do so that I am simply advancing a theory to account for indisputable facts—facts that must be admitted whether the theory be acknowledged or not.

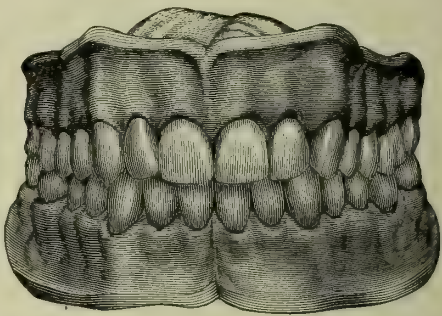
It will be allowed, I presume, that celluloid is cellular in construction. Now, as a consequence, when it is heated and expands its cells drink in the surrounding medium, just as a sponge drinks in water. If this medium be oil or glycerin, the cells are filled with it, and the subsequent pressure only serves to close their orifices without expelling the liquid. On cooling, consequently, the moisture throughout the interior of the substance softens the walls of the cells, and they crumble away. If steam be used, when the plate cools the vapor is condensed and its

expansive force becomes almost nothing, and therefore, in addition to the softening effects of the moisture, the walls of the cells are required to sustain the pressure of the atmosphere and of cohesion without any internal support. The celluloid ought, it would seem, therefore, to crumble even more rapidly. When, on the other hand, the plate is moulded in contact with dry air while the cells still imbibe the surrounding medium, it is a medium without moisture, and of at least considerable expansive force even when cooled. The plate therefore remains smooth and compact.

The following figures were originally prepared from practical cases for illustrating an article in the *Dental Cosmos*, July, 1880, but as they were made with single teeth mounted upon celluloid base, I will reproduce them to illustrate how perfectly this material with the use of single teeth can be moulded to restore expression in the human countenance. The illustrations are figured from practical models of characteristic mouths. Fig. 480 represents two sets of six front teeth from the same mould—one

FIG. 480.

FIG. 481.



as it leaves the mould and is found in stock; the other showing alterations by grinding to suit a different case. Figs. 481 and 484 represent two sets of mounted teeth, both from the same mould (shown in Fig. 480).

Fig. 481 represents a younger mouth than is often found requiring a full set of artificial teeth; but in order to show the different characteristics of youth and age which may be produced from the same set of teeth, I adopted for my model the denture of a young German lady patient of about eighteen years of age, reproducing the slight irregularities existing in her case. The artificial teeth illustrated in Fig. 480 were so well adapted to the case that very little modification by grinding was necessary, even the cusps of the bicuspids and molars scarcely requiring to be touched by the corundum wheel (see side-view, Fig.

FIG. 482.

482), thus enabling me to preserve the original form of the artificial teeth almost intact. The cutting edges have that beautiful rounded appearance so generally found in harmony with the general physique at this age, the serrations found at an earlier period having all disappeared. Fig. 483 shows a palatal view of the same case, and certainly indicates that a vast improvement of the grinding surfaces has been made by the manufacturer. The cusps and intervening sulci are clear and well formed, requiring in any case but little labor on the part of the dentist to make a most perfect occlusion. I will not discuss the palatal and dental arches of this case, as more distinctive ones are shown farther on.

FIG. 483.

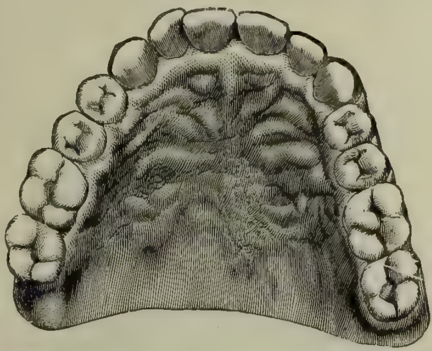


Fig. 484 shows the front view of a set of teeth for a male fifty or sixty years of age. It is somewhat of the Celtic order, though not what would be considered a pure type. We have in this case a "square bite" upon the cutting edges, producing slight abrasion, and with just enough irregularity to produce a pleasing effect. The gums show slight recession from the necks of the superior teeth, more marked in the inferior incisors and cuspids, and accompanied in the latter with a congestion of the gums, making the festoons more prominent than normal. The prominence over the superior canines will strike some as being too great, but, considering the inclination of the roots and the contraction of the arch back of the canines, it is not too marked, which is more clearly shown in Fig. 485, a side-view of the same case. In

FIG. 484.

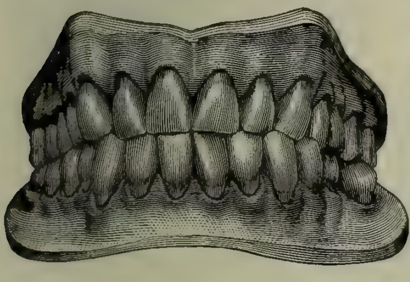
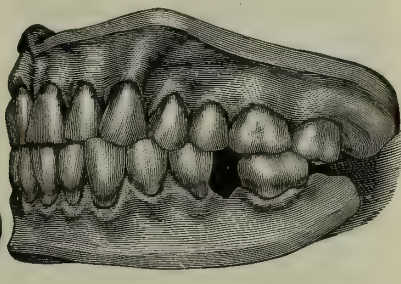


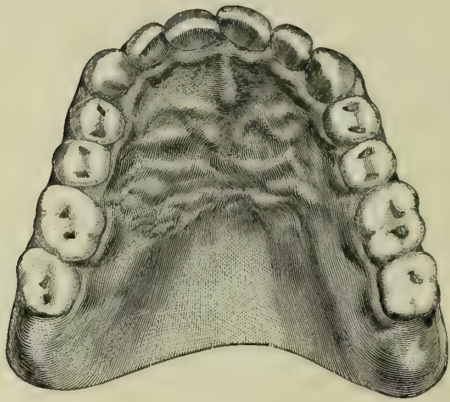
FIG. 485.



the lower maxilla the sixth-year molar is missing, and the twelfth-year molar has moved forward just enough to adjust itself to a solid occlusion, the absorption of the alveolar process causing a greater recession of the gums at the necks of the second bicuspid and molar than elsewhere. The abrasion of the cutting edges is best shown in Fig. 486, a palatal view of the same case, more marked upon the incisors and cus-

pids than upon the bicuspids and molars, owing to a perfect lock occlusion, as shown in Figs. 484 and 485. The cutting edges of the front teeth have been stained to imitate the effect of tobacco upon the denuded dentine. The rugæ in the cut show a direct transfer from the model upon which the case was mounted.

Fig. 486.



The modifications which can readily be made in the expression of a set of teeth by shading, by grinding, and in mounting will surprise any one who has not given thought to the subject and experimented in this direction. Fig. 487 illustrates what I consider a beautiful set of continuous-gum teeth, of what we may call the English type, but capable of wonderful modification when of different shades and ground and mounted with reference to different ages and other individual characteristics. The teeth are represented in the shape given to them by the mould. Fig. 488 shows the same teeth altered in expression by grinding the cutting edges and squaring the mesial surfaces, which gives an appearance of age. This effect can be carried to a lesser or greater degree to suit the individual case.

Fig. 487.

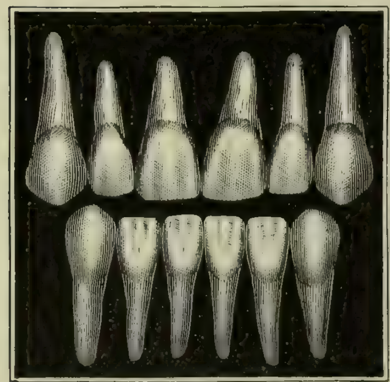


Fig. 488.

Fig. 489 is a mounted set from the same mould, and may represent a patient, say, of the Anglo-Saxon type twenty-five years of age—a broad, full, well-developed mouth, clear-cut, well-formed teeth, with no blemishes of imperfect enamel. In this set I have retained as nearly as possible the natural formation of the teeth as they come from the mould, to show a young mouth and to make the variations in the cases which

are to follow more distinctive. The superior centrals are thrown out slightly by the underlapping of the laterals. A slight irregularity of the four inferior front teeth has been made merely to avoid conventional uniformity and to disarm suspicion of artificiality. The jaws are shown a little apart in order to display the cutting edges more clearly. Figs. 490, 491, 492, 493, and 494 are illustrations of two cases kindly loaned to me by Dr. J. W. White. They represent teeth from the same mould as those of Fig. 487, and enable me to carry out this series. These cases show the wide range which this one set of teeth is capable of being made to cover. Fig. 490 may illustrate the mouth of an old gentleman, robust and vigorous, florid face, and evidently fond of good living. The shading of this set of teeth for such a case is perfect; the abrasion is well marked, and the irregularity of the lower incisors exceedingly natural. Fig. 491, a side-view of the same case, shows the irregularity even better than the front view. The loss of the left superior first bicuspid, creating the gap so frequently seen at this point in natural dentures, gives greater prominence to the cuspid, making it seem more indicative than before of strong animal passions. Fig. 492 is a palatal view of the same case.

Fig. 489.

Fig. 490.

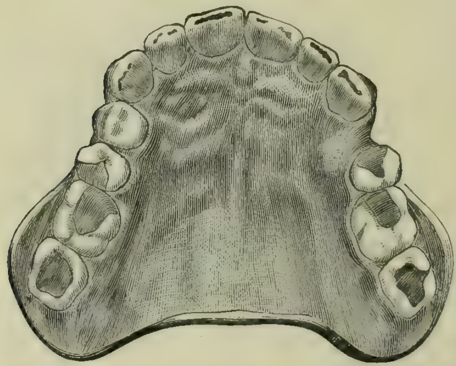
Fig. 493 shows the mouth of an individual past middle life and the recession of the gums so often seen now-a-days. The effect produced by the abrasion of the lower incisors and the separation of the centrals is exceedingly life-like, and well calculated to convey the impression of original ownership. Fig. 494 is a side-view of the same case.

Fig. 491.

No one who will take the trouble to compare, or rather to contrast, Figs. 489, 490, and 493, remembering that these three sets of teeth, so radically different from one another, were made from teeth out of the

same mould, can fail to be impressed with the thought that the blame for the "picket-fence" conventional dentures generally seen in the mouths of their wearers is not to be laid at the door of the manufacturer, but is to be attributed rather to the want of artistic taste in the routinists who mount them.

Fig. 492.



I present in Figs. 495 and 498 practical cases, the originals of which are now being worn in the mouth. They have been chosen on account of their extreme variation of characteristics, as representative of cases which frequently give much trouble and annoyance to the practitioner in the effort to secure as pleasing results as he and his patients would desire.

The first case is that of a young lady who lost all her natural teeth at the age of twenty-two. She came to me a few months ago with about twenty-three roots, several of them abscessed, all that remained of a once handsome denture. Her health had been seriously impaired by this condition of her mouth, and there was no choice but to remove the débris and give her the benefit of prosthetic dentistry. The result has been very satisfactory, she having gained nearly twenty pounds in weight in a little over three months, and having almost entirely recovered from the dyspepsia to which she had been a martyr. Here was a case in which an artificial denture was an absolute necessity.

Fig. 493.

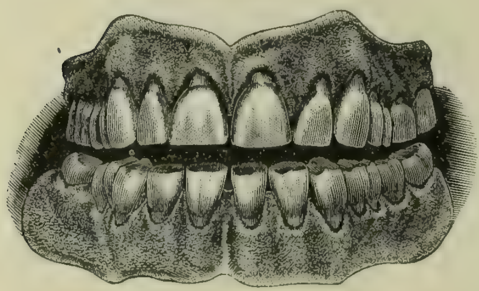


Fig. 494.

Fig. 495 is taken from the models to show the close articulation resulting from the prominent alveolar ridges left by the recent extraction of the teeth. The mouth is inclined toward what is termed the lambdoid type—V-shaped arch, etc.

Fig. 496 represents a front view of the set of teeth made for this patient. I always try to get an idea, by questioning my patient without letting the object appear, as to what the natural teeth were like,

Fig. 495.

Fig. 496.

regular or otherwise, to assist the judgment which I may form in my own mind from the face, models, etc. Acting on the information received and my idea of the facial requirements, we have a little protrusion of the upper front teeth, a slight irregularity in the lower teeth, and a little over-lapping of the centrals of the upper set by the laterals. The teeth are short and full, the six front ones being set directly on to the gums.

Fig. 497 gives a side-view of the same, showing more clearly why it is necessary to mount the upper front teeth directly upon the gums: First, because the recent extraction left prominent alveolar ridges; second, because the patient has a short thick upper lip, which would have been made more prominent, rigid, and unnatural-looking had the teeth been set outside the arch; third, had the lower teeth been thrown out sufficiently to meet the upper teeth, if these were mounted outside of the arch, the mouth would have presented the appearance of that of an herbivorous animal, and, moreover, such an arrangement would have made it impossible to hold the plates in position during mastication.

Fig. 497.

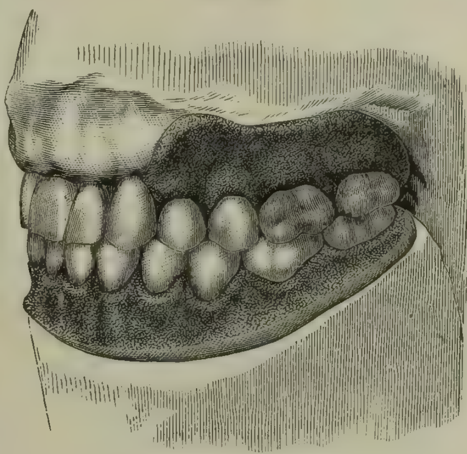


Fig. 498 shows the models of an old gentleman's case, in which there

is exactly an opposite condition of things from the preceding one—a rather full and very flat jaw, the alveolar ridges having been much absorbed, and a wide articulation being required to restore harmony of the features.

Fig. 499 is a front view of the set made for this case. It is peculiar, for many reasons. The patient was very eccentric, and, being will-

FIG. 498.

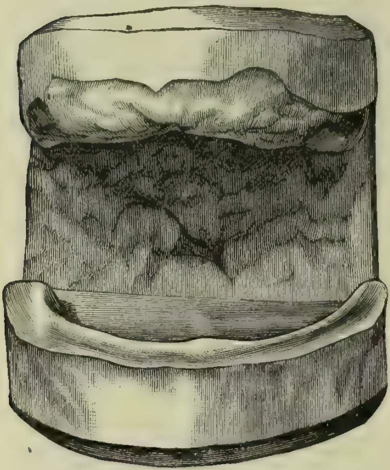


FIG. 499.

ing to pay liberally for the work, was humored a little. The plate was made of gold, attaching the teeth with celluloid. The teeth are of medium length, some of them represented as slightly exposed at the roots, especially the cuspids. A slight show of irregularity is made by allowing the laterals to rest behind the centrals. The cuspids are prominent and have rather a broad front. The buccal prominences were meant to slightly fill out the cheeks and to protect the soft parts from the springs.

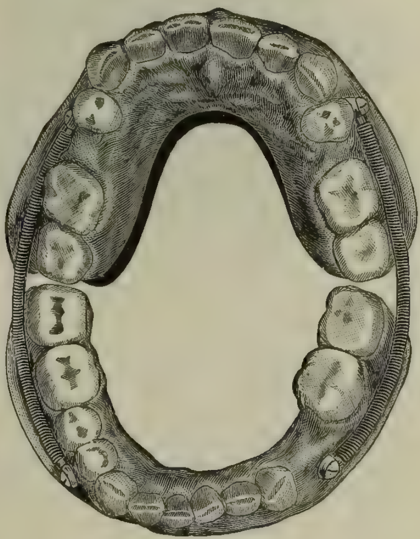
Fig. 500 presents a three-quarter view of the same case, showing the articulation to be on the cutting edges of the incisors, in imitation of the natural teeth. To give a more natural appearance, I left out the second superior bicuspid, indicating a lapse of time since its loss by representing the space as partially closed up by the moving forward of the molars. In the lower jaw both bicuspids are missing on the left side, while the molars have moved forward until stopped by the superior first bicuspids; the lower cuspid was unable to move backward by being locked between the superior cuspid and lateral. This illustration shows another view of the "plumpers" and springs.

FIG. 500.

Fig. 501 shows partly the reason for the use of springs; the mouth being very flat (see Fig. 498), hard, and dry, afforded little opportunity for a plate to be held by atmospheric pressure. The patient was nau-

seated by the slightest touch upon the posterior portion of the hard palate, and too irritable to allow of any efforts to overcome its susceptibility. Being an epicurean, and thoroughly convinced that with an ordinary plate he could not taste his food, some other method had to be resorted to. I therefore adopted the old European manner of attaching ivory blocks to the jaws—happily, a lucky expedient in this case. The engravings show the manner of applying the springs, and the shields for protecting the soft parts from irritation by them.

FIG. 501.



In Fig. 501 is seen the abraded cutting edges stained, the irregularities, the spaces left by the lost teeth, the relation of the teeth to each other, and the shape of the plates. The lower molars are leaning toward each other across the tongue, the incisors inclined forward, etc.—all tending to make the case as natural and comfortable in the mouth as possible.

The causes of spaces between the natural teeth may here be briefly considered. Dr. James W. White, in his little work entitled *The Mouth and the Teeth*, p. 41, says: "The teeth in man are arranged in close contact, without intervening spaces, affording each other mutual support after the manner of staves in a barrel. Being set without interspaces on a curved line, it follows that their outer surfaces are wider than the inner." If this is correct (and I assert that in ninety-nine cases out of a hundred it is), why should dentists and manufacturers persist in producing what is unnatural and disfiguring when correct models are so easily procured? If we are trying to imitate nature, to restore natural expression, why distort it? I used to condemn the manufacturers for the "picket-fence," sectional-block teeth, but I do so no longer. Dentists are themselves to blame.

FIG. 502.

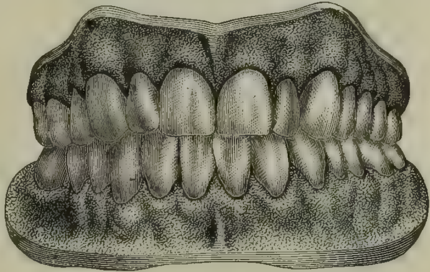


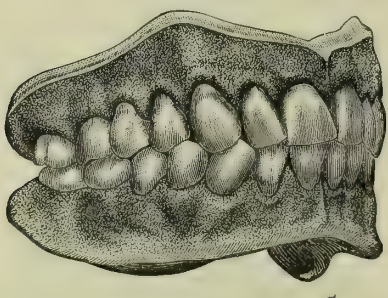
Fig. 502 is a front view of a case designed to show the causes for interspaces, though not doing so in this particular cut. The teeth are full and rounded, presenting a pleasing effect. The laterals lapping over the centrals are broad, accounting in part for their irregularity.

Fig. 503 is a side view of the same case. Here we have several spaces developed through the loss of teeth above and below. In the superior maxilla the second bicuspid is absent, while the first and second molars have moved forward and the first bicuspid settled backward, adjusting themselves to easy occlusion, and nearly filling up the space left by the lost tooth, but at the same time creating new interspaces between the first bicuspid and cuspid and first and second molars. The lateral is prevented from working backward by the inferior cuspid. In the lower maxilla the first molar has been lost, the second has moved slightly forward, locking between the superior first and second molars, while the second inferior bicuspid has settled backward—probably from the force of mastication—occluding comfortably with the first superior bicuspid and molar, but leaving another space between the first and second inferior bicuspids. In this mouth we have both crowding and interspaces, and causes for both.

Fig. 503.

Fig. 504 illustrates another frequent cause of interspaces—namely, locking of the teeth through occlusion. We have in this case nearly all the teeth bearing firmly against each other for support, and, as shown in the cut, almost a perfect occlusion from the cuspids back, though the point claiming our special attention is the interspaces on either side of the superior cuspid, which is slightly turned on its axis and is locked between the cusps of the cuspid and first bicuspid of the lower maxilla, precluding a possibility of its movement either forward or backward without artificial interference. The first superior bicuspid cannot come forward, owing to its nice occlusion with the first and second inferior bicuspids; the superior lateral cannot move backward, although crowded and overlapping the central, as it is forced forward and retained in position by the cusp of the inferior cuspid. So here, again, the interspaces are caused by malposition.

Fig. 504.



The present style of setting artificial teeth is found in nature as the result of amalgamation—German and American, English and Eastern, American and aboriginal. In such cases there is likely to be an inequality of development between the upper and lower maxillary bones, one jaw partaking of the characteristics of the father, the other of the mother. The result generally is overcrowding or irregularity, but we sometimes find cases such as is shown in Fig. 505. Here is a well-developed inferior dental arch, with proportionately well-developed teeth

characteristic of one parent, while in the superior dental arch the teeth resemble those possessed by the other parent, and are too small in proportion to the size of the jaw. The result is interspaces between nearly all of the teeth in the superior dental arch.

Fig. 505.

Fig. 506 is a side view, displaying these defects, the cusps of the superior falling in between those of the inferior teeth.

But I find that I am drifting away from my original intention, which was to illustrate by a few cuts how artificial teeth may be made to look comparatively natural under careful manipulation and a little study of the natural organs and of the human face. And so I return to "why I like zylonite." The few preceding cuts only go to illustrate how well this material is adapted to meet the idiosyncrasies of our patients; and I must admit that, so far as my individual experience goes, this material in combination with single teeth and mounted on metallic lining has given me more real satisfaction than any other base that I have used. I have not had an opportunity of testing the zylonite under the microscope as I have the celluloid proper, but I have learned sufficient to know that it is far superior in every particular as the two are now presented to the profession. The color is better, and always uniform: celluloid is not uniform in color, sometimes running into a very objectionable greenish tinge. By comparing the two you will notice a translucency or depth to the surface of the zylonite not found on the celluloid, which has a thoroughly dead surface.

Fig. 506.

The celluloid has a tendency to scale or disintegrate unless the blanks are very carefully selected. This is not the case with zylonite; nor have I noticed any tendency to soften or "wash out," as some call it, from the pins which poor celluloid is accused of.

Finally, the deduction I make is, that the zylonite company, having benefited by the experience of other manufacturers of this material, having in their employ experienced, careful, and faithful managers or foremen, have attained an excellence in the manufacture, first, of the dinitro-cellulose, which is so delicate a process; secondly, in the perfect admixture of the necessary ingredients to make the compound, resulting in an article that is uniform under all vicissitudes of weather, possessing great resiliency, beauty, and diminished inflammability.

ARTIFICIAL CROWNS (PIVOT TEETH).

By WILLIAM H. TRUEMAN, D. D. S.

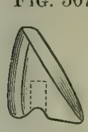
The term "pivot tooth," although in general use and thoroughly understood, is a misnomer. A pivot is, properly, a pointed centre or bearing upon which something revolves. The piece of wood or metal uniting a natural or artificial crown to a root is really a dowel or a dowel-pin, the latter being defined by Webster to be "a piece of wood or metal used for joining two pieces by inserting part of its length into one piece, the rest of it entering a corresponding hole in the other." This definition fully describes the function of the piece of wood or metal uniting an artificial crown to a root. The inappropriateness of the expression "pivot" is now becoming recognized, and as technical terms "pivot teeth" and "pivoting" are gradually being suppressed in favor of the more correct form, "artificial crowns" and "crown setting."

The origin of the operation is unknown. As far back as its history can be traced it is referred to as an operation in general use, its merits and demerits are familiarly discussed, and improvements suggested or commended; but in no case is the operation itself spoken of as new or novel. Probably it was among the first dental operations attempted. The exposed position of the anterior teeth renders them liable to be broken off by accident: in such case we may readily conceive that the very noticeable deformity caused by the sudden loss of a conspicuous tooth would naturally beget a desire for its replacement; an examination, revealing an opening in the crown portion broken away, and a corresponding one in the root portion remaining fixed in the jaw, would quite as naturally suggest its replacement by inserting a dowel in these two openings conveniently placed for its reception: indeed, "the untutored mind" might see in this one of the many bountiful provisions of nature. In cases where the missing portion was too badly broken for replacement or had been lost by the ravages of decay it would be but a step to replace the lost crown by the corresponding portion of another tooth, or, where this could not be obtained, by something nearly resembling it. The crown portion of human teeth or the teeth of inferior animals, or artificial crowns carved from ivory, bone, or hard wood, were, so far as known, exclusively used until about 1774, when mineral or "incorruptible teeth" were introduced; indeed, they were in general use until long after that date. So many were the difficulties encountered and so slow the progress in perfecting this new idea that only within the last fifty years have artificial crowns of porcelain been so far improved in

strength, appearance, and adaptability as to entirely supersede them. It is related that M. Duchateau, an apothecary of St. Germaine, France, in 1774, being disgusted with the unpleasant odor from the ivory artificial teeth he was then wearing, conceived the idea of reproducing them in porcelain. His first efforts with the material used by porcelain manufacturers were unsuccessful, owing to its excessive contraction during the process of baking. He persevered, however, experimenting with various compositions in the effort to overcome this difficulty, and with the assistance of M. de Chemant, at that time a dentist in Paris, after several years' persistent effort finally so far succeeded that the merit of this new material was fully recognized. Others are credited with making the attempt at a much earlier .date, but I think it is generally admitted by writers upon the subject that the introduction of porcelain artificial teeth dates from the efforts and experiments of these two gentlemen.

Although the records that have been preserved are quite meagre, they seem to indicate that the earlier efforts were directed to the construction of the plate and teeth in one piece or to the reproduction in porcelain of the teeth and plates then in general use carved from ivory. The shrinkage of the porcelain in baking rendered this extremely difficult, and led to the teeth being made separately, to be afterward mounted upon metal or other plates. It was not long, however, before "mineral teeth" as they were then called, were made to be engrafted upon roots. They did not prove as successful as were those designed for plates. Not only were they clumsy and badly shaped, but the dowel holes were imperfectly formed; their smooth vitrified sides failed to hold the dowel as securely as did the natural crowns; if the dowel was fitted sufficiently tight to be secure the crown invariably split, the porcelain of which it was made being deficient in strength. These teeth (see Fig. 507) were not formed in closed moulds, as porcelain teeth are now made; the face only was moulded, the back or lingual surface being moulded and shaped with the fingers; they were simply blocks of porcelain rudely resembling the teeth, and required, when fitting them to the root, a great deal of grinding to make them conform in size and shape to the crowns they replaced. In addition to this, the porcelain then used was opaque, uniform in color, and lacked the life-like tints and vital appearance with which we are now familiar. The progressive improvements were slow: it was not until Samuel Stockton, the father of the dental manufacturing business in this country, began, about 1830, the manufacture of artificial teeth on an extended scale that porcelain crowns of a desirable character were produced. Those he made at this early date were in some respects better adapted to the purpose than those of a later day. The dowel hole was deeper and of better form and more conveniently placed. Neatly mounted, they looked remarkably well. The large dowel they permitted and the excellent material of which they were made gave them a greater permanency than usually attends like operations with those at present attainable.

Fig. 507.



Crown for Central Incisor, made in France about 1800.

During the last few years increasing attention has been given by the

dental profession to the preservation of the natural teeth: encouraged by the success attending these efforts, their energies have been directed to the replacement, by other methods than the usual plate covering a portion of the palatal surface, of those which have been lost or those so seriously injured by accident or the ravages of disease that their repair by any process of filling would either fail to restore their usefulness or render them undesirably conspicuous. Where the root has been previously extracted artificial crowns have been inserted—the replaced teeth being a fixture or removable at the patient's pleasure—by attaching them to a root or to an adjoining tooth or teeth. This method of replacement is known as "bridge-work," and will be fully treated in a separate article. I shall therefore confine my remarks to those methods by which an artificial crown is firmly attached to a root for the purpose of replacing the lost natural crown only, and not with the view of making it serve as an anchorage or support for other teeth.

I will first consider the method of replacement where the attachment of the crown to the root is by means of a dowel fitting tightly an opening in the tooth and root prepared for its reception, or firmly held in each by some one of the plastic cements used in filling.

The teeth prepared for use by these methods are invariably made of porcelain, and require no preparation previous to insertion further than being ground to fit accurately the root and to permit proper occlusion of the opposing tooth or teeth. On this account they are generally known as "all-porcelain" crowns, in contradistinction to those used by other methods in which the porcelain crown is soldered to a metallic plate or cap covering the exposed end of the root, and having firmly soldered to it a stem or dowel passing into the root, by which it is retained. Occasionally, but seldom with satisfactory results, this metallic cap or plate is replaced by one of vulcanized rubber.

Dr. W. G. A. Bonwill of Philadelphia has invented many ingenious improvements in the form, construction, and attachment of "all-porcelain" crowns: these are fully treated in the article written by Dr. Bonwill, and on that account are omitted from this.

I will now proceed to describe the various methods of inserting artificial crowns—first, by means of a dowel or by means closely allied to it; and secondly, those methods in which the dowel is replaced by a metallic stem soldered or otherwise secured to the crown. It is not my intention to treat the subject exhaustively, but rather to select the more typical methods and those which have proved or promise to be practically useful: this will include but few of the many that have been published from time to time.

In the older methods of preparing a root for the reception of a natural or an artificial crown carved from ivory, etc. the exposed end was made from side to side, concave in shape, and shortened, so as to be a little below the level of the gum, the free margin of which when the operation was completed covered the joint between the crown and the root. The crown was then fitted to the root so as to make a solid and close joint, leaving no space for the entrance of food, etc. The pulp-canal was enlarged, to accommodate the dowel, either before or after the root was shaped. Hickory, locust, or other hard, close-grained wood, condensed by being

forced through draw-plates, was generally used for the dowel; some operators preferred to strengthen this by passing through it a gold wire, the wood being retained outside of the wire for convenience of fitting it to the hole in the root and crown; others preferred to dispense with the wood if the crown was a natural one or one carved from bone or ivory, screwing the wire into it or fastening it to an artificial (porcelain) crown by means of a fusible cement. The portion entering the root was secured in place by wrapping with cotton or silk, or by first inserting a plug of wood in the root, drilling a hole in the centre of this into which the dowel was driven, it having been first filed square and to a sharp point. After the porcelain crown had been so far improved as to be really practical, the wood dowel, on account of its convenience, was almost exclusively used.

The more modern method of inserting a porcelain crown in this manner is as follows: After the root has been properly treated and the more prominent projecting portions removed, freely open and somewhat enlarge the pulp-canal; if this is deferred until the root has been cut away for the reception of the crown, the bleeding of the gums, which usually is quite profuse, interferes very much with the preparation of the canal. The next step is to permanently close, by filling with gold, gutta-percha, or other preferred root-filling, that portion of the canal toward the apical foramen not occupied by the dowel. I assume that previous to this a suitable tooth has been selected. In addition to the points presently to be suggested upon selecting teeth, we have also to see that the hole in the tooth for the dowel is well formed, and that it corresponds, approximately at least, in size and position with the hole in the root, and that the base of the crown fully covers the face of the root. As a rule, in these teeth as now made the dowel hole is too small, and quite frequently is imperfectly formed. It should be perfectly cylindrical with parallel sides, and as deep as the size of the tooth will admit. The face of the root may be cut away by means of suitable tools in the dental engine or by an oval root-file (Fig. 508), so that the joint between it and the crown will be below the level of the gum all around: it should also be made concave from side to side to prevent rotation of the crown. When the root is nearly prepared, by means of a temporary dowel of soft wood adjust the tooth to place. We now see how nearly the dowel hole in the root and the crown

FIG. 508.

Various Sizes and Forms of Root Files.

correspond in position and direction. If the canal has not been enlarged to the full size required, it may, if they do not exactly conform, be made in a measure to correspond with the hole in the crown. This being done, and the hole made as deep as the size and strength of the root will permit, the face of the root is shaped as desired, and the crown fitted to it so as to make a close, solid joint: in doing this we may remove from the crown or the root as may be most convenient. It is very important that the crown should fit the root solidly: if it does not, in addition to any vacancy furnishing a lodgment-place for food, etc., it increases materially the strain upon the dowel. After the tooth is satisfactorily fitted to place see that it is free from forcible contact with the antagonizing teeth when the jaws are tightly closed and during the various movements of mastication, and that it does not project to any marked extent beyond the face of the root at any point. The crown is then ready for final insertion.

Select the piece of wood for the dowel, being careful that it contains no natural defect and that during the process of condensing and reducing in size it has received no injury impairing its strength. Some recommend thoroughly saturating the dowel with creasote, supposing that it is thus made more indestructible: I very much doubt its utility. The permanancy of the operation depends largely upon the accuracy and care with which the dowel is fitted. It is seldom that the hole in the root and crown exactly correspond in size, position, and direction: it requires a nice judgment to allow for slight variations when shaping the dowel. At times the difference is so great as to severely tax the operator's skill to so shape it as to hold the tooth-crown in its proper position. The temporary dowel will suggest the shape of the permanent one. To make the permanent dowel select a piece of prepared wood sufficiently large in diameter to fit the hole in the root, and fit one end of this into the hole in the crown, neatly forming a shoulder that will fit closely the under side of the crown when the end of the dowel is quite to the bottom of the hole in the crown. To ascertain this, allow it to be a trifle too long when fitting: this will keep the shoulder on the dowel from fitting closely to the base of the crown, and will show exactly how much it is too long; if preferred, a gauge may be used.[1] It should be fitted accurately rather than tightly; the sides should be smooth and parallel, and fit the hole in the crown at all points. If made to fit too tightly, especially if the wood is quite dry, there is danger of the dowel splitting the crown when it expands or swells, as it will do when exposed to the moisture of the mouth. When the dowel is fitted and inserted in the crown, the next step is to cut it off the right length to fit into the root. This may be ascertained by the gauge. It is well, however, to cut it a trifle long. Then reduce the diameter of the dowel so that it will go into the hole in the root without more than a slight pressure; reduce the length, if need be, to allow the tooth to

[1] This gauge consists of a wire of a size freely to enter the dowel hole, having a slide with flange attached moving upon it quite stiffly. By introducing this wire into the dowel hole, and moving the slide so that the flange rests upon the face of the root, the depth of the hole is indicated at once. The gauge shown in Fig. 513, while differing from the form usually used, answers the purpose equally well.

fit closely to the root; place the tooth in position, and the operation is complete. If the hole in the root and the crown do not correspond in direction, this must be provided for by using a larger dowel, and when fitting it to the root cutting it away at such an angle as will bring the tooth into the desired position. Some recommend bending the wood with the pliers to accommodate such cases: of this I cannot approve. By this method the wood is strained and weakened at a point where strength is most needed. If the hole in the root is larger than that in the crown, the difficulty is overcome by fitting each end of the dowel independently, as recommended. It frequently happens that when the holes are directly opposite the tooth may be either inside or outside the arch; this is readily provided for by using a piece of wood rather larger than the diameter of the hole: when fitting it into the crown, instead of removing equally all around, remove all from one side: by repeating this when fitting the other end of the dowel into the root, making each end of the dowel eccentric to the other, quite a noticeable change in this respect may be made. There is, of course, a slight loss of strength whenever the dowel is shaped otherwise than perfectly straight, but unless the irregular form is excessive it is so slight to be of no moment.

The wood dowel holds much more firmly in the root than in the crown: it is not necessary, therefore, to make it fit the root so tightly: if the sides are parallel and fit the root accurately, if so fitted that the fingers unaided can press it into place, it will be held with sufficient firmness. If fitted too tightly there is not only danger of splitting the root, but the pressure will quite frequently excite serious pericemental irritation: why it should do so in a healthy root with the foramen thoroughly closed it is difficult to explain.

The wood used for dowels is usually quite dry: when exposed to moisture it swells or expands to a marked degree, exerting a force almost irresistible when this tendency to expand is restrained. We depend upon this swelling of the wood to hold the crown firm, and avoid its destructive action by fitting the dowel loosely. Various expedients have been suggested to make a closer joint between the crown and the root: a few thicknesses of gold-foil, a thin sheet of gutta-percha, various cements, etc. have been recommended. The gold-foil I consider worse than useless, and the other suggestions of doubtful utility when a wood dowel is used. It is far better to make an accurate joint, and to cut away the root so as to bring the joint well below the level of the gum; the gum will then usually close around it and assist very materially in keeping it clean. There is usually but little difficulty in securing the wood dowel in either the crown or the root: the great objection to its use, apart from the impossibility of making an absolutely impervious joint between the crown and the root, is its liability to break or twist off in a comparatively short time.

This method of inserting crowns can seldom be used upon other than the six anterior teeth. Of late years, on account of improvements in form and method of setting promising greater permanency and cleanliness in artificial crowns, it has fallen into disuse. I have, however, frequently seen cases where crowns inserted with wood dowels have

been quite firm after five to ten years' service, and cases will often occur where this method can still be used to advantage. It may be modified by using, in place of the wood dowel, a gold wire fitting the hole in the root and crown loosely. This wire should be well barbed throughout its length, and secured in the root with gutta-percha, the crown being afterward affixed with zinc-phosphate cement; or the wire may be coated with the cement, a little being placed in the hole in the root and crown, and the crown be quickly pressed into place and held until the cement has set. This makes a neat and strong setting. The wire may be bent in any direction and to any extent necessary to place the tooth in proper position: if care is used to make a close joint, so that the cement is not exposed to the secretions of the mouth, it usually proves quite durable.

Closely allied to this is a method suggested by Dr. Charles H. Mack, then of Portland, Oregon. Dr. Mack devised and patented,[1] for retaining fillings in large or badly-shaped cavities, a system of screws and instruments for their insertion; these he also used to secure in place a specially-designed artificial crown (patent No. 123,271, dated Jan. 30, 1872). These (Figs. 509, 510) closely resembled the crowns used with the wood dowel, except that the hole for the dowel, instead of being cylindrical, is made oblong, the long diameter antero-posteriorly. The crown is fitted to the root precisely in the same manner as in the method just described. In place of a wood dowel, however, Dr. Mack places in the root two gold screws, screwing them firmly into the dentine on either side of the pulp-canal if convenient to do so, or where this cannot be done fastening them into the pulp-canal with a zinc-oxychloride, gutta-percha, fusible-metal, amalgam, or other cement, allowing the free ends to project so far beyond the face of the root that when the crown is placed in position they will pass into and extend nearly to the bottom of the dowel hole. They are placed as far apart as the dowel hole will permit, and the ends flattened, if need be, so as to freely enter it. When the crown is satisfactorily fitted and the screws are firmly in place, the cement selected is worked thoroughly around them and into the dowel hole in the crown, and the crown is quickly placed in position and firmly held until the cement sets. Crowns were made for this method to replace the six anterior and the bicuspid teeth. Used as suggested by Dr. Mack, they have not proved as satisfactory as was expected: they were made far too small at the base to well cover an average root: this impaired their stability. The screws did not pass far enough into the crown to hold securely, the strain upon the cement causing it to quickly break away. The Mack crowns for anterior roots, while still occasionally useful, have been superseded by other and more desirable forms: the bicuspid crowns, however, by replacing the screws with a dowel of heavy gold plate inserted as follows, will prove satisfactory in many cases: Make and fit into the root a wedge-shaped dowel of gold plate, No. 20 or 22 (Fig. 511), the wide part fitting loosely into the dowel hole of the crown, and when the crown is in position sufficiently long to fully occupy it and to pass into the root as far as possible. If the root is

FIG. 509.

FIG. 510.

FIG. 509. Mack Crown for Incisor Tooth.
FIG. 510. Mack Crown for Bicuspid Teeth.

[1] Patent No. 114,454. (See *Dental Cosmos*, vol. xiv. p. 684.)

bifurcated, ream each canal so as to make them as nearly as possible parallel; fit a separate dowel into each, bevelling the approximating edges so that they neatly fit; secure them firmly together while in position in the root, preferably by imbedding the free ends in plaster; remove, invest, and solder them together, afterward dressing down the soldered portion to fit into the crown. This makes, where the canal is bifurcated, a very satisfactory arrangement for any method of inserting artificial crowns where dowels are used, and will securely hold in a root that otherwise could not be used. In preparing the root the free end is cut away a little below the level of the gum, and is made slightly concave. The crown is fitted to it as closely and as accurately as possible. When prepared, insert the dowel in the root, and dress down its free end so as to allow the crown to be placed over it in precisely the same position it occupied without it; this should be carefully done, the dowel being made to fit snugly yet loosely the opening made in the crown to receive it. Make, with a small wheel burr in the dental engine or with a sharp, short-bladed excavator, retaining-grooves on the sides of the dowel hole in the root; barb the dowel, especially the portion passing into the root; place a little softened gutta-percha (such as is used for filling, that known as "base plate" answers equally well) in the crown, and, warming the dowel, press it into it, but not quite to its final position; place softened gutta-percha upon the portion fitting into the root, using rather more than will be needed. After thoroughly drying the root and its surroundings, warm the crown and dowel so as to make the gutta-percha thoroughly plastic, and immediately place it in position in the mouth, pressing it to the root with a firm, steady pressure, and holding it until the gutta-percha begins to harden: this may be hastened by injecting cold water upon the crown. When thoroughly chilled the surplus that has pressed out may be neatly cut off with a thin-bladed instrument made as hot as can be borne: a hot instrument cuts it off neatly, while one only warm is apt to drag it from under the crown. If this trimming is left until the next day, when the gutta-percha will be thoroughly hard, it can be as neatly done with a sharp instrument used cold. I used this method long before these crowns were made, using crowns hand-carved especially for the case, and have had them to last for from ten to fifteen years without renewal or the slightest attention. They are easily inserted, and make a neat, strong, and cleanly operation.

FIG. 511.

Dowel for a Mack Crown.

The screw, so useful in the mechanic arts, has been repeatedly suggested for securing artificial crowns to roots. Robert Wooffendal, in a work published at London in 1783, speaks of the use of a screw of gold or silver for this purpose; and from that time to the present, modified in many ways, it has been repeatedly used, generally with unsatisfactory results. Theoretically, nothing seems more feasible than the screw; practically, the fine thread made by machinists' taps and tap-plates is useless in dentine. If it were possible to put the screw in so tightly that the screw would act in a measure as a tap, it might prove of some service. This cannot be done: the attempt would extract all but the firmest roots, and would seriously endanger these. The hole must first

be made sufficiently large for the tap to pass in easily: when the thread is made not only is it quite shallow, but it also is imperfectly formed; the dentine in the mouth is too soft to permit the cutting of so fine a thread. The screw also must fit easily to avoid undue strain upon the root. It does not require a skilled mechanic to predict that a screw fitted and used under these conditions must fail. To secure better results, some have fixed the dowel into the root by other means, threading the projecting end and fitting to it a nut by which the crown was secured; or this has been reversed, a nut being secured in the root and the screw used to draw the crown and root together. In this case the thread upon the screw and nut may be perfectly made, and were it possible to screw the fixture firmly in place it no doubt would answer the purpose; but until some means can be devised of supporting the root while the screw is made tight the practical difficulty will continue: screw them as firmly together as we can, it is impossible to use sufficient force to break down the roughness always found upon even a well-made screw, and bring the metallic surfaces so closely together that it will not work loose under the strain of constant use. To appreciate this it is only necessary to compare the force required and used in turning a fine watch-screw "home" and the rotative force that can be used with safety upon an average root. I do not consider it necessary to describe the various methods that have been invented and reinvented from time to time of using screws for this purpose: they are now of little or no practical value.

Dr. W. Storer How[1] of Philadelphia has devised a simple method of mounting artificial crowns that is quite original and complete. He has thoroughly studied the various conditions to be met, and provided for nearly all cases of replacement likely to occur. He has also devised a set of instruments to facilitate the work. To secure the crown to the root he depends mainly upon a peculiarily threaded screw-post: this is assisted, however, by an amalgam filling forming the lingual surface and thoroughly dovetailed into the crown and root. The thread upon the screw-post (shown very much enlarged in Fig. 512) resembles closely the usual thread of a wood screw, the threads being quite sharp and thin, wide apart, and the valleys between rounded and smooth. The form of the thread is very different from that heretofore used, and is well adapted for the purpose: with a sharp, well-made tap there need be no difficulty in forming a perfect thread in the root, and there is no doubt that the screw-posts will hold firmly. The form of thread causing less friction, the post can be screwed in the root firmly without imposing upon it a serious strain. The thread upon the post is not cut, but formed by a process of rolling, by which it is claimed greater uniformity of size and a much smoother surface are obtained: the burr or roughness previously referred to, always found upon a screw formed by cutting, is by this process avoided.

FIG. 512.

In mounting a crown by this method first measure the depth of the pulp-canal by means of the root-plugger (Fig. 513) and its flexible

[1] *Dental Cosmos*, vol. xxv. p. 179 (April, 1883).

gauge (Fig. 514), and fill the canal at and a short distance from the apex of the root, the distance which it has been filled being readily determined by the gauge. Then cut off the remains of the crown and pre-

FIG. 513. FIG. 514. FIG. 515. FIG. 516. FIG. 517. FIG. 518. FIG. 519. FIG. 520.

3

Twist Drill.

Drill Chuck.

Face of Root, showing groove to retain the amalgam.

Tap.

Tap Chuck.

FIG. 513. Root-Plugger, with gauge in position.
FIG. 514. Flexible Gauge.
FIG. 515. Gates's Drill, with gauge in position.

pare the face of the root as previously described for other methods. The instruments to which I now refer are specially designed for this work and are intended to follow each other. The drills enlarge the pulp-canal to the exact size the tap requires, and this in turn prepares the hole for the reception of the screw-post. Set the gauge (Fig. 514) on a Gates drill (Fig. 515) the depth it is desired the screw-post shall pass into the root, and drill to that depth. Set the twist drill (Fig. 516) in its chuck (Fig. 517), to project the same length as did the Gates drill, and, turning the chuck with the thumb and finger, drill the root to exactly that depth. Enlarge the mouth of the canal one-sixteenth of an inch deep all around to near the margin of the root, using for this purpose a suitable burr in the dental engine, and then with an oval burr undercut a groove at the sides and lingually, as shown in Fig. 518. This is designed to secure anchorage for the amalgam which forms the lingual surface of the crown when finished. Set the tap (Fig. 519) in its chuck (Fig. 520) a trifle less in length than the drill; oil the tap, and carefully tap to the gauged depth. Insert the post in its chuck (Fig. 521) to the exact gauge of the tap, and turn the thumb-screw hard on the end of the post; then screw the post into the root, release the thumb-screw, unscrew the chuck

a half turn, bend the post until the chuck stands in centre line with the adjoining teeth, and unscrew the chuck. The patient is now directed to close the teeth, and the post is excised and ground off until the teeth close clear of the post. The method of setting the post is the same in all cases. The teeth designed for this method are shown at Fig. 522. The lingual aspect is recessed to accommodate the post, and also to form an undercut into which the amalgam is packed : they are provided with four long platinum pins which are to be bent so as to clasp the post tightly. They are made for the six anterior teeth. Cuspid crowns are used to replace the bicuspid teeth, the backing of amalgam being contoured to form the inner cusp. The crown having been selected, proceed to fit it in place. Try the crown on the post, and with a thin corundum disk, dry, grind the rib between the neck-pins until the crown is labially flush with the root-margin, carefully cutting a little at a time until exactly flush.

Take the crown and place the mandrel (Fig. 523) between the pins, just as the post is to be, as shown in Fig. 524, and with the pliers (Figs. 525, 526) bend the pins carefully over the mandrel, cutting off the pins if too long to be pinched in on the mandrel at the sides, observing that the pin nearest the cutting edge is first to be bent (Fig. 527), and

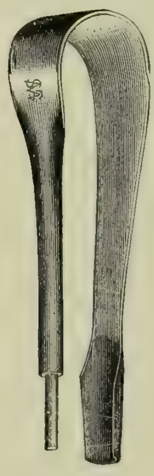
Fig. 521.

Chuck for Post.

Fig. 522.

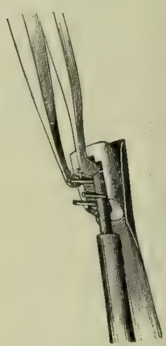
How Tooth-crown.

Fig. 523.



Mandrel.

Fig. 524.



Mandrel, with tooth-crown in position.

Fig. 525.

Pliers.

Fig. 526.

Pliers.

the opposite pin bent below it on the mandrel ; and so with the others. Slip the crown over the post, try occlusion, and with the post-chuck bend the post until the crown is properly aligned with the teeth ; then with a small corundum wheel grind the neck of the crown to a close labial fit with the root, fitting only the portion to be concealed by the gum, leaving narrow gaps at the sides to be filled by the backing between crown and root (Fig. 528). Grind the cutting edge for relation to the other teeth, making sure the opposing tooth does not strike the crown, post, or pins. Fix the crown on the post by pinching the pins into the screw-threads

of the post with the pliers (Fig. 525, 526). Finally, pack the backing of cement or amalgam into all the crevices around the post and behind and under the pins and between the crown and root; contour and finish thoroughly, so that no ledge or other imperfection can be found. Fig.

FIG. 527.

Showing how the pins are bent to fit around the post.

FIG. 528.

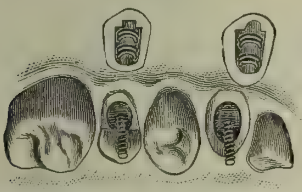
Tooth-crown fitted to root.

FIG. 529.

Crown complete.

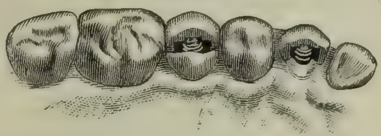
529 shows in vertical mid-section an incisor crown mounted, the blackened portions of the backing defining the locking-hold of the backing on the post, the crown-pins, and the root-recess. Fig. 530 shows in perspective a cuspid crown ready to be slipped over its post, and also a cuspid crown ready for its post in the bicuspid root, which has its lingual cusp remaining; and Fig. 531 shows the crowns on their posts awaiting the contour backing.

FIG. 530.



Cuspid and Bicuspid Roots, with posts inserted to receive the crown, and the crowns, with pins properly bent, ready to be slipped over them.

FIG. 531.



The Crowns in Position, ready for the contour backing of amalgam.

In completing the bicuspid crown (Fig. 531) amalgam is carefully packed between the natural and artificial cusp, and built out to the natural form of the tooth. When it is desired to contour a cuspid crown to form an inner cusp upon a bicuspid root or to adapt a cuspid or incisor crown for masticating uses, the pins may be twisted together over the mandrel, and again twisted tightly over the post, as in Fig. 532; in some cases it may be better to bend the neck-pins, as in Fig. 533, instead of twisting them. In all cases the bent pins are to be pinched quite hard over the mandrel and post, so that the serrations of the pliers will roughen the pins to prevent their being pulled through the backing, which should also be condensed around the pins and post. A sharp bend of each pin-end will perhaps best prevent pulling out.

When the root is much decayed the bottom of the cone-shaped cavity may be drilled and tapped to the depth of a sixteenth of an inch, and the post, thus anchored, may be further secured by cement or amalgam in

the grooved walls of the cavity and around the post, as shown in Fig. 534.

In some cases it may be necessary to grind the post flat on the crown side after it has been set and bent in the root (Fig. 535), so as to be clear

Fig. 532.

Fig. 533.

Fig. 534.

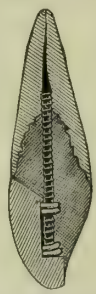
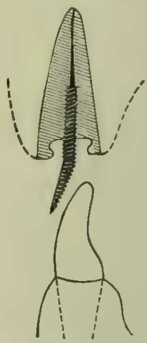


Fig. 535.



Figs. 532, 533. Pins twisted so as to retain more firmly the amalgam backing.
Fig. 534. Method of Inserting Crown when the root is much decayed.
Fig. 535. The post filed flat to clear an occluding tooth.

of the occluding tooth; and then the crown-pins may be bent over the reduced post, the crown fitted and ground to clear the opposing tooth (Fig. 536), and the backing added.

A similar case, in which the opposing tooth and a proper alignment require an oblique bending of the pins, is seen in Fig. 537, while the reverse arrangement of parts is shown in Fig. 538. The crown is thus

Fig. 536.

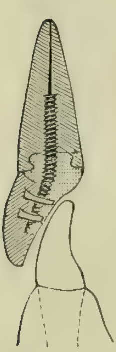


Fig. 537.

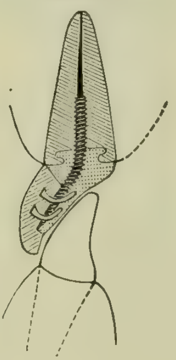


Fig. 538.

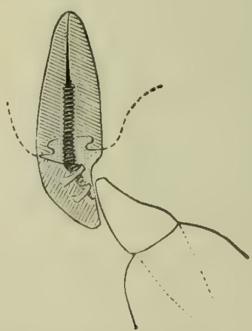


Fig. 539.

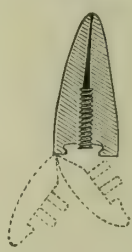


Fig. 536. Method of setting Crown to clear an opposing tooth.
Fig. 537. The Crown set Obliquely, to avoid opposing tooth.
Fig. 538. Crown set so as to lean in.
Fig. 539. Shows the extreme range of adjustment of the How tooth-crown.

seen to be adapted to a wide range of adjustments, because its point of contact with the root is at the labial portion of the neck, on which, as on a hinge, the crown may be swung out or in, as shown by the dotted lines in Fig. 539.

The labio-cervical junction is made just under the gingival margin, a

thin layer of cement, amalgam, or gutta-percha being interposed: the joint is made smooth and is hid from view under the free margin of the gums.

The handles of the tap-chucks and post-chucks are made of small diameter to ensure that too great force shall not be used with the thumb and finger in turning the tap and post; and it is enjoined upon the operator to remove the tap when it begins to turn at all hard, and repeat the removal until it has been easily turned down to the gauged depth. The cuttings must be carefully blown or wiped out, so that the post may be easily turned down to the bottom of the hole without risk of splitting the root, as there is danger of doing with too great a force acting on the débris as a wedge; hence this caution to employ only a reasonable amount of force and to do thorough work.

Dr. How has also designed an all-porcelain dovetail crown for the roots of bicuspids and molars only, using for attachment the same screw-posts which form so prominent a feature in the method just given. Dr. How thus describes his method of mounting them:[1]

"Fig. 540 shows the roots of an inferior molar after the apical portions have been filled, the neck recessed, the canals drilled and tapped, and two How screw-posts firmly fixed therein, the ends of the posts having been pinched toward each other by means of a pair of pliers, so that they will go through the central opening in the crown (Fig. 541). This opening is of a dovetail form, as shown in cross-section by Fig. 542, where the crown is seen in place over the posts on the root. It is thus made obvious that the crown may be easily put on and off the root in the process of fitting the crown-neck to the root-neck, and also that, for occlusion, the crown may be ground low on any or all sides without destroying the dovetail function of the central cavity. When the fit-

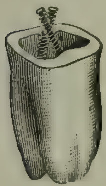
FIG. 540.


FIG. 541.

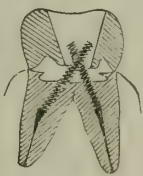

FIG. 542.


FIG. 543.

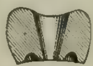
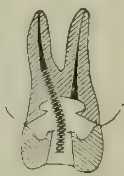

FIG. 544.


FIG. 545.


ting is completed and the crown cut so short as to be one-thirty-second of an inch distant from the occluding tooth, amalgam is packed into the neck recess, around the posts, and thinly over the cervical margin of the root, the crown put in place, and, with thumb pressure, firmly seated. Then test the occlusion, and complete the operation by packing amalgam into the crown opening, which will permit the forcing of the amalgam in all directions to ensure a firm base for the crown and its secure dovetail attachment to the posts, as is clearly shown by Fig. 542.

"The bicuspid crown (Figs. 543, 544) is similarly mounted, as may be seen in Fig. 545, cross-section, the same crown and root being shown in contour by Fig. 546. In some instances this bicuspid crown may, like

[1] See *Dental Cosmos*, vol. xxvi. (1884), p. 464.

the Foster crown, be secured by a headed screw, as shown in Fig. 547. The root having been drilled and tapped and recessed, and the crown properly fitted and articulated, the screw is put through the crown, amalgam packed in the crown-groove and around the screw, which is then inserted in the root and the crown pressed hard into its place. The screw is then turned into the position shown in Fig. 547, thus com-

Fig. 546.

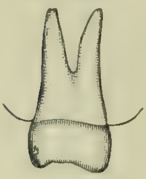


Fig. 547.

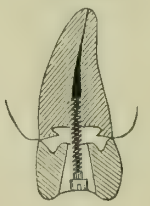


Fig. 548.

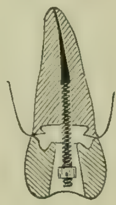
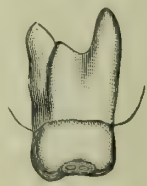


Fig. 549.



pressing the amalgam or cement in both recess and groove, after which the screw-head may be covered with amalgam, cement, or gold as desired.

"As a preferable mode, however, the screw-post may first be fixed in the root, the crown adjusted over the post, amalgam packed on the root and around the post, the crown seated firmly, more amalgam packed in the crown-cavity around the post, and then a nut screwed on the post, as shown in Fig. 548. In all the sectional cuts cement, amalgam, or gutta-percha is to be understood as filling the cavities in the conjoined roots and crowns.

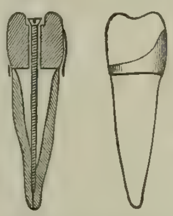
"Fig. 549 shows in contour a dovetailed crown mounted on a superior molar root in the manner shown by Fig. 542. It is obvious that the crown of Fig. 542 might be ground quite down to the post-ends, and yet be firmly held by the dovetail sides of the central cavity."

Dr. Edward C. Kirk of Philadelphia has devised a method of engrafting all-porcelain crowns upon frail roots of single-rooted teeth, in which he supports and protects the frail portion of the root by means of a gold collar encircling the root. He also uses a screw as a dowel, depending, however, for firmness of attachment upon a cement in which it is imbedded. The following is Dr. Kirk's description of his method:

"The root is prepared in the usual manner by carefully closing the apical foramen with gold or gutta-percha and removing all softened dentine from the canal, which is then undercut or roughened with a wheel-burr. The apical end of the pulp-canal is enlarged by a drill, and a thread cut in the dentine by means of one of How's drill taps. Only a small portion of the upper end of the canal is so tapped—just sufficient to engage from a sixteenth to an eighth of an inch of the end of the screw-post, as dependence is placed mainly upon the cement lining for anchorage. A collar of 22-carat gold, No. 30, having its edges smoothly bevelled, is accurately fitted to the end of the root and driven tightly on to it, until it extends somewhat over one thirty-second of an inch under the gum. The collar is cut short upon the labial side and left long upon the lingual side, so that it extends nearly to the grinding surface of the lingual cusp of the finished crown, but is visible only as a

narrow band upon the buccal surface at the gingival margin. When the band has been satisfactorily adapted in the manner described, a Foster crown, which has been previously adapted to the end of the root by careful grinding, is adjusted inside the root-collar. The crown selected should have a greater circumference than the end of the root, so that by grinding it down somewhat conically on its lingual and proximal surfaces it can be tightly adjusted to the collar. If a crown smaller than the collar is taken, a tight joint cannot be made. When the crown has been carefully fitted to its place, a tight joint secured, and the proper occlusion obtained, a gold screw, with a head upon it similar to the ordinary gimlet-pointed wood screw, is passed through the central opening in the crown, carried up until it engages in the dentine at the apical end of the root, and driven home with a small screw-driver, and its proper length adjusted, so that it firmly holds the crown and band in their proper relations to the root, as seen in Fig. 550. When all has been satisfactorily adjusted the screw and crown are removed, and the root-canal, band, and surrounding parts thoroughly dried; the crown is to be permanently attached by filling the root-canal full of slow-setting oxyphosphate of zinc, mixed rather thin: the crown is then pressed firmly into its place, when the excess of cement will flow through the central opening in the crown; the gold screw is then to be passed through the crown and driven quickly to its seat by the screw-driver, all excess of cement passing out, as before, through the central opening of the crown and alongside the screw. After the cement has hardened all excess is cut from around the screw-head by means of an excavator, after which the screw-head is covered and the countersunk opening in the crown filled with gold, anchorage for the filling being obtained by cutting a groove around the base of the screw-head by means of a small wheel-burr." The completed operation is shown in Fig. 551.

Fig. 550. Fig. 551.



Dr. Kirk's Method of Retaining Tooth-crowns.

Dr. Horatio C. Meriam of Salem, Mass.,[1] suggests that the forms of ready-made porcelain crowns at present offered in the dental dépôts are faulty, in that strength is sacrificed to construction. In order that they may be readily and easily adapted to a large number of cases the hole for the dowel and the recess at the base are made unnecessarily large; they are still further weakened in the effort to secure an accurate fit to the root: it is necessary in order to accomplish this to grind them so much that the tooth-structure is encroached upon. To avoid this, he proposes a crown that may be ground on its sides as well as on the portion fitted against the root; the crown to have a straight hole through it, similar to that of the English tube teeth, except that in the incisors and cuspids the hole should come out at a greater distance from the cutting edge. After the crown is fitted to the root this hole may be enlarged, countersunk, or bevelled at either end as may be most convenient, or the hole may be omitted when the crown is made, and be drilled in the desired position after it is fitted to the root. He proposes to accomplish this by

[1] *Dental Cosmos,* vol. xxviii. p. 493 (Aug., 1886).

means of small suitably-shaped corundum points or specially-prepared drills capable of drilling porcelain readily. In Fig. 552 are shown some of the varieties that can be made by grinding such a crown. With these crowns it is expected that dowels will be used, set in either cement or gutta-percha. He also suggests that these crowns may be

FIG. 552.

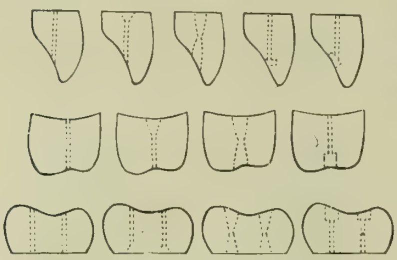


FIG. 553.

FIG. 552. Variation in the Form of a Tooth-crown which may be made by grinding.
FIG. 553. Form of Tooth-crown to be secured to the root by a metallic band.

attached to the root by metallic bands fitted either to the root or the crown, without the trouble and delay of investing and soldering, using for this purpose the form shown in Fig. 552 or those shown in Fig. 553, by the following method, which I quote:

"The band is fitted to the root, and the crown ground into the band after proper occlusion with its antagonist has been obtained. If a molar, a fine groove is ground around it, and the band, after being corrugated on its inner surface with a small burr, is placed on a lead anvil and the tooth driven into it, thus partially securing the advantage of union by gomphosis. The common glass stopper is a good illustration of how little more than its fit would be required to retain it firmly in place. For this little I have drawn on the tube-teeth workers of England. A few small pieces of sulphur are then placed inside the band, and all held over a small flame until the sulphur melts and flows into the groove between the band and the crown. Zinc phosphate may be used before the crown is forced in, or some flux—borax, for instance, which melts at a low temperature, though this would probably require investing.

FIG. 554.

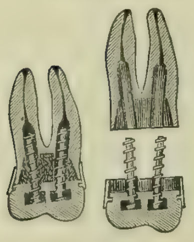


FIG. 555.

FIG. 556.

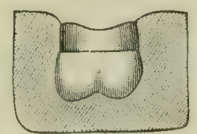


FIG. 557.

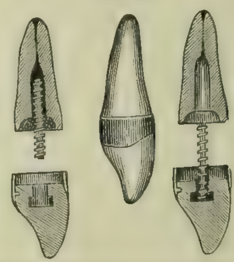


FIG. 558.

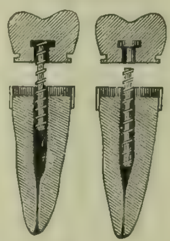


FIG. 554. Tooth-crown secured by metallic band and dowels.
FIG. 555. Crown with Groove for Wire.
FIG. 556. Crown Invested for Soldering.
FIG. 557. Anterior Crown with metallic bands.
FIG. 558. Bicuspid Tooth-crowns with dowels and metallic band.

We then have a crown which, if a molar, I do not fear to attach with gutta-percha without dowels; but others may not have this confidence,

and dowels may either be put into the roots or be set in the crown with cement, and afterward secured to their places in the root as usual (Fig. 554). It is evident that if cement is strong enough to hold a dowel in the root, it must be equally serviceable in securing the crown to the dowel. If greater security is desired, a fine platinum or pure gold wire may be fitted into the groove around the crown (Fig. 555). Drive in as before; invest and solder (Fig. 556). For the incisors the groove should not run around the anterior face of the crown, and I have not soldered these teeth in (Fig. 557). I have entire confidence in any form for the incisors and bicuspids where the root is well banded, the dowel put into the centre, and the crown forced into place in gutta-percha (Fig. 558); while for the molars, if quite short, I do not care for the dowels. You will notice that this method does away with much of the showing of gold in molars where such a result is desired (Fig. 559).

"I suggest another form for molars, which although showing more gold than the others, I think is perhaps stronger. The band is made full width down to occlusion, and any large strong tooth is ground to fit the space in the arch. This is driven into the band so as to be even with its edge, and cemented with sulphur as before (Fig. 560).

"*Setting.*—I first varnish the band inside with Canada balsam dissolved in ether; then fill the crown with gutta-percha and crowd it up against the root several times to get an impression. When sure that I have the right amount of gutta-percha, I place the dowels in the root (if I am to use them), heat the crown, dip it into cajeput or any essential oil, and crowd it to place. The dowels I fit in the same way, wrapping them with gutta-percha and working up and down in the root until

FIG. 559.

FIG. 560.

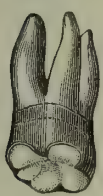


FIG. 561.

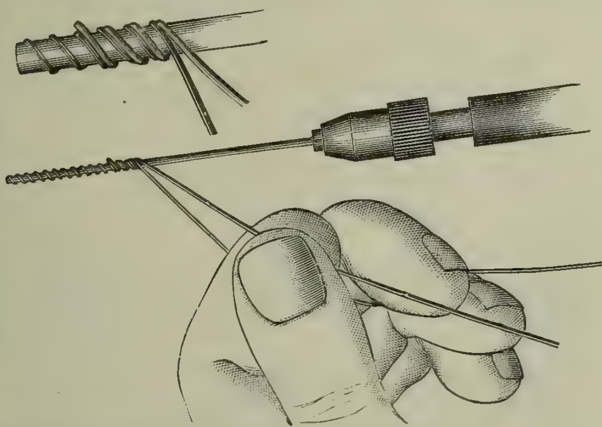


FIG. 559. Molar Tooth-crown secured by a narrow metallic band.
FIG. 560. Molar Tooth-crown secured with a metallic band.
FIG. 561. Method of Making the Dowel.

I get the impression before the final forcing to place. I thus have the advantage of the dowel and hard centre of gutta-percha to act as a plunger, and the soft, semi-dissolved gutta-percha comes back on the outside of the mass, forming, I think, the tightest root-filling known. I fill roots in this way with gutta-percha points when I do not use a dowel.

The dowels used are made by wrapping a piece of platinum and iridium wire with about one-third of a sheet of gold-foil, which is melted on, and the combination made true by being drawn once through a wire-gauge. A piece of piano-wire is then wound around it three or four times to serve as a guide, and a fine platinum wire, previously drawn square, is caught and turned through the wire-guide a few times, when the winding may either be finished by hand, or the end, after being started, may be placed in a lathe-chuck and wound up at once (Fig. 561). A piece of gold-foil is then wrapped around the whole and the fine wire soldered on. A dowel made in this manner is not strained by having its thread cut, and the thread, being square and coarse or fine as you wish, is strong and possesses plenty of grip.

"When a root has broken off far under the gum, it should be filled with gutta-percha, and a temporary plate worn—if the loss be in the front of the mouth—until the root works down, when it may be crowned and the plate given up.

"In preparing roots after a large portion of the crown is broken away, I enlarge the pulp-chamber with a large, round burr, and, when even with the gum, follow with the revolving saw here shown (Fig. 562). With this saw I often cut off the remnants of a crown from the inside without wounding the gum or drawing a drop of blood, and am saved the unpleasantness of running a stump corundum wheel in the mouth. The outside of the root can sometimes be formed with the instruments here shown (Fig. 563)."

Fig. 562.

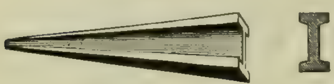
Fig. 563.

Fig. 562. Revolving Saw for cutting off roots.
Fig. 563. Files for shaping the outer edge of roots.

This method of inserting artificial crowns is suggestive, but I seriously doubt its practical usefulness. In setting crowns with gutta-percha the use of varnish or any medium that partially dissolves the gutta-percha I consider decidedly objectionable. In practice the solvent does not quickly evaporate and leave the gutta-percha as firm and hard as it was before it was applied; and as a result we have a layer of partially-softened gutta-percha at the very point where we most need its strength and toughness to make the operation secure.

Dr. M. L. Logan of Tyrone, Pa., invented and patented an artificial crown in which one end of the dowel is imbedded and baked into the crown during the process of manufacture. These tooth-crowns may be obtained to replace all the teeth. In order to facilitate the accurate fitting of the crown without encroaching upon the post or dowel, the base is deeply recessed, leaving a thin border, to be fitted to the root as seen in Fig. 569. The platinum dowel or post is made of peculiar shape, plainly shown in Fig. 564. This not only gives it a maximum of strength with a minimum of metal, but also causes it to be held more firmly in the cement, and in the case of a bifurcated bicuspid root it is readily split into two por-

Fig. 564.



Dowel of the Logan Crowns.

tions, which may be bent to pass into each canal, as seen in Figs. 571 and 572. Dr. W. Storer How gives the following directions for their insertion:[1]

"Fig. 565 shows a superior right central root, an end appearance of the same, and a Logan crown, front view. Fig. 566 exhibits, at a

FIG. 565.

FIG. 566.

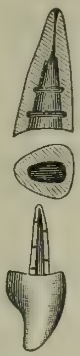


FIG. 567.

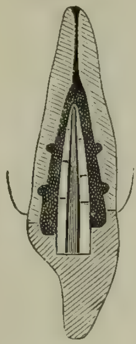


FIG. 568.

FIG. 565. Section and End of Root and Logan Crown, front view.
FIG. 566. Section and End of Root and Logan Crown, side view.
FIG. 567. Section of Logan Crown adjusted to the root.
FIG. 568. Front View of Logan Crown in position.

right angle to the plane of the first figure, the same root, its end, and the Logan crown, side view. In both figures the pulp-canal is supposed to have been first drilled to a gauged depth with an engine twist drill, and then enlarged by means of a fissure-burr to the tapering form shown, the walls being subsequently grooved with an oval or wheel-

FIG. 569.

FIG. 570.

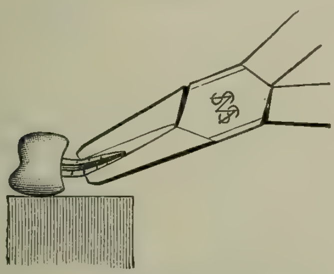


FIG. 571.

FIG. 572.

FIG. 569. Logan Crown with the post bent for adjustment to a bifurcated bicuspid root.
FIG. 570. Method of bending the post or dowel.
FIG. 571. Logan Crown with the post split for adjustment to a bifurcated bicuspid root.
FIG. 572. Logan Crown with the post split, in position.

burr. The enlarged section (Fig. 567) shows the crown adjusted on the root by means of cement or gutta-percha, which surrounds the post and fills all the spaces in the root and crown. Fig. 568 shows the completed crown. Fig. 569 exhibits a bifurcated bicuspid root, its end appearance, and a Logan crown adjusted to the root. Fig. 570 illus-

[1] *Dental Cosmos*, vol. xxviii. (Aug., 1886).

trates the best method of bending the post. Fig. 571 shows a Logan crown with its post split, and its adaptation to a bifurcated bicuspid root is seen in Fig. 572. Figs. 573 and 574 exhibit the mode of

FIG. 573.

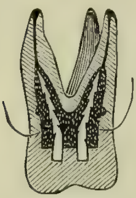


FIG. 574.

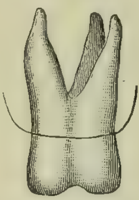


FIG. 575.

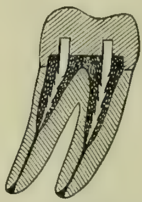
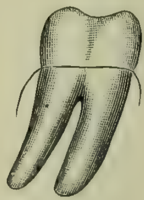


FIG. 576.



FIGS. 573, 574. Method of Mounting a Logan Crown upon a superior molar root.
FIGS. 575, 576. Method of Mounting a Logan Crown upon an inferior molar root.

mounting the Logan crown on a superior molar root, and Figs. 575 and 576 the same crown in its relations to an inferior molar root.

"In the light of the preceding descriptions the figures clearly present to the mind's eye of the expert dentist the essential features of the new Logan crown and the method of mounting it; yet further explanation with reference to the figures will perhaps prove serviceable to such as may not be familiar with all the details of root-crowning.

"In every instance where a root is deemed ready to receive its filling it should first be measured through its canal from the cervical opening to the apical foramen, and this may be accurately done with a gauge adjustable on a delicate canal-explorer. The same device serves to measure the distance from the apex to which the canal should be then filled (Fig. 577). It also gauges the depth to which the drill may be carried. The proper degree of enlargement from the bottom of the drilled hole will, of course, depend on the observed size and character of the root; and every dentist should familiarize himself with generic tooth-forms, so that when the length of an incisor, cuspid, or other tooth-root is known, he can so nearly determine its hidden outlines as to form with precision a corresponding enlargement of the pulp-canal, such as is shown by the several cuts. The suitable preparation of the bifurcated roots of some bicuspids and of all the molars is a matter involving difficulties and requiring judgment of an unusual character. An instance of the feasibility of splitting the post of a Logan crown to adapt it to the bifurcated root of a bicuspid is shown by Figs. 571 and 572. This example directs attention to the peculiar shape of the post, in which there is effected such a distribution of its metal that its greatest strength is in the line of the greatest stress that will in use be brought to bear on the crown, while the least metal is found at the point of the least strain, the applied part of the post being in outline nearly correspondent to that of the root itself. The pulp-canal is likewise conformably enlarged to receive the largest and stiffest post compatible with the size and shape of the root to be crowned.

"The fitting of a Logan crown to a root is best done by the use of a wet stump-wheel in the engine hand-piece, which affords the greatest facility for the slight touches required to abrade the thin cervical bor-

ders of the crown, which may thus be made without encroachment on the post.

"By the old method of adapting pivot teeth to roots the close fitting of the crown precluded the use of a plastic packing, because its thinness over the surface of the joint made such packing liable to break loose under the shock and strain of use. The recess in the Logan crown obviates this defect by providing a receptacle for a considerable interior body of cement that will be deep enough to be self-sustaining internally, and yet allow the peripheral portions of the root and crown to approach each other so closely that, though only a film of packing remain, it will still be strong enough to ensure the persistent tightness of the joint. Such annular boss of cement when formed of amalgam also adds strength in some cases to the mount.

"When enough of the natural crown remains, it is well to leave standing some of the palatal portion, and cut the root under the gum-margin at only the labial part, as shown by Fig. 578. Thus, the labial joining of the root and crown will be concealed, and the other parts of the joint will be accessible for finishing and keeping clean. (See Fig. 579.) The Logan crown may be ground until a large part shall have been removed for adaptation to the occluding tooth or teeth without greatly impairing its strength. (See Fig. 580.) This crown also in

Fig. 577.

Fig. 578.

Fig. 579.

Fig. 580.

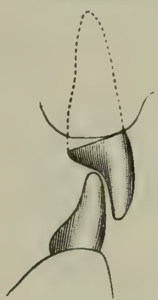


Fig. 581.

Fig. 577. Method of Using the Gauge to determine the depth of root-filling.
Figs. 578, 579. Manner of Shaping the End of the Root, so as to make the joint accessible for cleaning and finishing.
Fig. 580. Logan Crown ground on labial surface to avoid an occluding tooth.
Fig. 581. Logan Crown in combination with a gold collar around the root.

such cases maintains the translucency which is one of its peculiar excellences, owing to its solid porcelain body and the absence of a metallic backing or an interior largely filled with cement or amalgam.

"The distal buccal root of the natural superior molar is in nearly every instance too small to receive a post of any useful diameter, and therefore the Logan superior molar crown has but two posts, which, like those of the inferior molar crown, are square, and thus may be easily barbed, as may also the ribbed posts of the crowns for the anterior tooth-roots. These posts are in all the Logan crowns large enough to answer in any given case, and can of course be easily reduced to suit thin or short roots.

"Any of the cements or amalgams may be used in fixing these crowns,

but good gutta-percha, softened at a low heat and quickly wrapped around the heated crown-post, which is at once seated in the root, forms the best mounting medium, and has the great advantage of permitting a readjustment, or if need be the ready removal, of the crown, by grasping it with a pair of hot pliers or forceps, and holding it until the gutta-percha is sufficiently softened.

"An excellent combination for some cases is accomplished by fitting a narrow gold collar over the neck of a root prepared like that of Fig. 578, and then adjusting and mounting, in the manner described, a Logan crown, with the result shown by Fig. 581."

Artificial Crowns Soldered to Dowels or Retaining-Pins.

I will now proceed to describe the methods in which the dowel or retaining-post or pin is soldered to the crown. It is not definitely known when this method of replacement was first used: it is noticed, however, so soon after the introduction of mineral teeth that I am inclined to believe it followed very shortly after that time. It is probable that the difficulty of fitting and retaining wooden dowels in the rudely-shaped crowns then made first suggested it. Figs. 582–584 illustrate teeth in the writer's possession which are intended to be soldered to metallic dowels; these are said to be specimens of the earliest mineral teeth made. They were probably made about 1800, and are of French manufacture. Fig. 582 is a rudely-shaped central tooth-crown with a dowel hole in the usual place, but passing entirely through the tooth: at the opening nearest the cutting edge is inserted on either side a little platinum ear by which it is intended that the tooth shall be soldered to the dowel passing through. Fig. 583 is another, having in the base of the tooth a deep groove to receive the upper end of the dowel, on either side of which are platinum ears to be soldered to it. Fig. 584 is a tooth in which the groove is wider and V-shaped: the palatal face is provided with two platinum pins; this is intended to be soldered to a plate covering the root, in much the same way in which they are now made. These are not what would now be known as plate teeth: they were made to be engrafted upon roots, and were used for this purpose and in some forms of bridge-work in use at that time.

Fig. 582.

Fig. 583.

Fig. 584.

Teeth of French Manufacture, made for use as crowns, and for use in some of the earlier forms of bridge-work.

It is probable that the difficulty of mounting natural and porcelain crowns in cases where the hole in the crown and the root could not be brought reasonably well in line, or in cases where the opposing tooth required the attached crown to be either very thin or very short, suggested the use of plate teeth with dowels soldered to them as soon as plate teeth were made. Writers upon dental art early in the present century give detailed descriptions of mounting the old-style French teeth —the very first plate teeth made—as pivot teeth, referring to it not as a new or novel idea, but rather describing it as a method in general use. These teeth (Fig. 585) were little more than slabs of porcelain, convex

on the face and roughly approximating the form of the teeth, they being thus constructed with a view to their being given the desired shape by the dentist; and the older works give directions for grinding them to shape and afterward polishing the ground surfaces. The backs of these teeth were perfectly flat, with a half-round perpendicular groove in the centre, on either side of which were little projecting ears or cramps of thin platinum plate imbedded in the tooth. A half-round gold wire was fitted into this groove, either before or after the tooth was fitted to the root, and bent so that it would pass up the root and also lay in place against the tooth. Then the little platinum cramps were bent over it and soldered, thus uniting the tooth and dowel.

FIG. 585.

Early Form of Plate Tooth.

If a neater result was desired, a plate of gold was fitted to cover the back of the tooth and secured by a second soldering. In some cases this was curved out so as to cover the end of the root, or the tooth was mounted upon a small gold plate fitted to the root and soldered to the dowel, making a really neat arrangement.

Teeth were also made for this purpose in which the groove was omitted, three little ears of platinum being inserted near the base of the tooth, to which the dowel and plate were soldered. The retaining-post was secured in the root either by making it fit tightly, or by wrapping it with silk, or by first fitting the root with a wooden plug and drilling in this a hole into which the gold pin was driven. With but slight changes this process, described so long ago, is recognized to-day as the best and strongest method of inserting artificial plate teeth on roots. While the general idea has been preserved, the method has been modified from time to time as greater proficiency in working with porcelain teeth has been acquired: science too has furnished new materials, and at the same time the general advance of our profession, the introduction of improved instruments, etc., permit the old to be used with greater accuracy and skill.

As naturally happens when many minds are at work to achieve a desired end, and especially in a profession whose advance has been so rapid as that of dentistry, it is almost impossible to do justice and give credit to all who have contributed to any given improvement. Indeed, in the class of operations under consideration it is difficult to give even a correct consecutive history of the various steps by which the present stage of improvement has been reached, much less divide the honors among those who contest the originality of each separate idea. I shall therefore, in giving the various methods, confine my remarks to practical points alone.

The advantage of using plate teeth with metallic dowels soldered to them was early recognized: they were found to be convenient of adaptation in cases where the roots were in an abnormal position, and also to have greater strength, owing to the dowel and tooth being securely united. The weak point, too, in all other methods then known—the attachment of the dowel to the tooth—was avoided: the dowel, being made of metal, remained unchanged by the secretions of the mouth, and thus was far more permanent than where wood was

used; but there still remained a difficulty in securing such metallic dowels, or retaining-posts, in the roots. The desire to secure a smoother finish on the lingual surface and to make a more accurate joint, and also to protect the root from decay, led to the use of a small plate made to fit the face or free surface of the root. This was found to give greater stability and neatness, but the wooden plug was still needed to secure the gold or platinum post in the root. On the introduction of amalgam it was at once utilized as a setting or cement for this purpose The gold mounting was replaced by platinum, and after the root was filled with soft amalgam a steel instrument was thrust into it, and the platinum post, pointed and barbed, was driven into the opening thus made. This was the first method that secured all the essential points now recognized as desirable in crown-setting. All the materials used had a high degree of stability, and were not liable to change or decay, as were vegetable fibres or natural teeth. The roots, too, were protected from decay as fully as a tooth could be by filling. The joint was perfect, leaving no space for the accumulation of food, as did all previous methods; indeed, the facility with which the work could be done and the permanency it promised seemed to leave very little to be desired.

Unfortunately, the peculiarities of this new material were not understood, and this ignorance of its nature and of its faults, and the almost total absence of correct information concerning the pathological conditions so often met with in roots on which this operation was attempted, led to so many disastrous results—all of which were charged to the amalgam, in most cases unjustly—that its use for this purpose was very soon generally abandoned. A few continued to use it, and by seeking to overcome the causes of failure finally succeeded in obtaining excellent results.

Where dowels were driven into roots or forced in with considerable pressure the importance of waiting until, as the writers then termed it, "all soreness and tenderness had passed away," was recognized, as was also the difficulty of using for this purpose roots badly decayed, and, as we now know, if not already abscessed, in a condition which rendered them very liable to give serious trouble if any operation was attempted upon them without proper preparatory treatment. The importance of waiting until the roots were placed in a healthy condition was not appreciated; indeed, the treatment they needed was not generally known, and was practised by comparatively few. These hopeless cases of badly-decayed roots were the chosen candidates for this new amalgam process, and indiscriminately, without regard to their condition, they were filled with the material, poorly prepared, containing, perhaps, four or five times as much mercury as it should have done. The result was soon seen. Those roots which were in a diseased condition almost immediately gave evidence of pericemental irritation. The abscess that had been quietly discharging through the pulp-canal, perhaps for years, immediately became, when this passage was closed, the seat of a new inflammatory process, and the results, with scarcely an exception, were the assignment of the cause of the trouble to some poisonous property of the mercury in the amalgam, and the prompt extraction of the root. In a few cases where the operation was tolerated the amalgam, contain-

ing so large an excess of mercury, contracted in setting, leaving a large space between it and the root; decay recommenced and progressed rapidly, this being accepted as another evidence of the worthlessness of the material. Although so complete a failure, it called attention to two points heretofore neglected: the importance of protecting the root from decay, and the desirability of something more cleanly than an ordinary artificial crown with a wooden dowel.

In order to secure cleanliness various methods were proposed for so arranging the tooth that it could be removed and replaced by the patient. The metallic post was split, and the two halves sprung apart, so that it was held in place by the pressure these exerted against the sides of the cavity in the root. Naturally, this caused considerable wear, and, allowing the secretions of the mouth free access to the root under conditions favoring their destructive action, decay was inevitable. These results suggested the lining of the hole in the root with gold.

A thin tube, generally made of gold, was prepared. It was at first made cylindrical in shape, but as this allowed the tooth to rotate an oval or square tube was recommended. This was secured in the root in various ways. The lower end of the tube was made to fit tightly or a screw-thread was cut upon it, a corresponding one being made at the bottom of the cavity in the root to hold it securely, while gold was packed around it and built to a level with the end of the root. For greater security the tube was barbed, so that the gold would hold it firmly. When the filling was completed it was filed down level, a post was fitted to the tube, a plate was made to fit accurately and just cover the face of the root, and was then soldered to the post and the tooth mounted upon it. If it was desired to have the tooth movable, the post was split; if a fixture was wanted, a little cotton or floss silk was wrapped around the post, which was thus held for a time quite firmly, the cotton or silk being readily renewed.

In practice this method was found faulty; the screw did not hold: as has already been explained, it is very difficult to cut a good thread in a root in the mouth with the taps usually used for that purpose. The dentine of the tooth behaves very much like soft wood, and with all the care that can be used the threads break away so much that the hold they furnish is slight. And, again, if the screw is made to fit the corresponding threads in the root tightly, the effort required to screw it in, tending to rotate the root, is not only painful, but in some cases would almost extract it, or at least cause severe irritation. As there is no way of supporting the root to assist it in resisting this strain, the screw must therefore be made to fit easily, and hence there is always a slight space between the tube and the dentine of the root as far as the screw extends. It is difficult to fill the space between the tube and the root when the root is badly decayed so that decay will not recur; and in a strong root the increased size of the cavity that must be made to accommodate the tube and the filling around it seriously impairs its strength. These delicate operations required a great deal of time and skill, and frequently failed in a few years, generally from decay around the filling; sometimes, without decay, in spite of the screw and the retaining points or grooves, the tube and gold came out bodily, this probably being due either to the fact that

the thin walls of the root did not permit the gold to be packed solidly, or to a slight elasticity in the dentine, which allowed the force of mastication to gradually loosen the appliance without causing any fracture or visible injury: occasionally such appliances failed from splitting of the root.

The improved plastic materials for filling teeth, and their application to the securing of the post in the root, have rendered all these various devices obsolete. They are interesting simply as matters of history: it is doubtful if they have any practical value now in any conceivable case. It is a matter of surprise that so much thought, time, labor, and skill should have been spent in devising means to secure the dowel firmly in the root, and that so many devices, complicated and difficult to construct, should have been used, when a little gutta-percha or properly prepared amalgam would have made the arrangements described by the early writers practically as good, so far as securing the dowel in the root is concerned, as the best we can do to-day. It is especially surprising when we remember that these plastic preparations were used for filling cavities of decay, and that their value for that purpose was recognized long before these complicated devices were invented.

The idea of making artificial crowns so that they can be removed and replaced by the patient in order to ensure cleanliness is not practical, nor does it secure the object desired. They cannot be kept firm for any great length of time, and to facilitate removal must necessarily be made so loose that there is always a considerable space for the accumulation of food, etc. between the dowel and the walls of the tube in which it slides. It is impossible for the patient to keep this space clean, and such teeth soon become quite as unpleasant as those with wooden dowels: neither have I seen any method of arranging the tooth on this plan that gave the root itself any greater protection from decay than did the wooden dowel.

In inserting an artificial crown the protection of the root is a very important matter: not only must it be protected from decay, but also from any strain, either from the pressure required to retain the dowel or from the force of mastication acting upon it through the crown and its attachments. Immunity from decay may be secured by holding the metallic dowel in the tooth by a cement or other plastic filling-material, this in turn being protected and held in place by a small cap or plate just covering the face of the root. This plate also in a measure relieves the root from strain—entirely from that caused by the pressure required to hold the dowel in place—and it distributes the force transmitted through the tooth in occlusion, the little plate having a firm and even bearing upon the face of the root: the strain upon the dowel being thus much lessened, the liability of the root to splitting is correspondingly reduced.

There are various methods now in use for inserting artificial plate teeth upon natural roots. The most simple method is to back the tooth with a heavy piece of plate, either gold, silver, or platinum (the latter if amalgam is to be used), and to leave it long enough to form the dowel, filing the end that goes into the root so that it will readily pass into the enlarged pulp-canal, and bending it so as to bring the tooth

into proper position; or the dowel may be a piece of wire soldered to the backing at the same time that the backing is soldered to the tooth, or the wire may be soldered to the tooth and the backing be dispensed with, as in Fig. 586. The fixture may be held in the root by any of the plastic filling-materials: if amalgam is selected, it may be built over the root, so as to give it a measure of protection from decay. This makes a rather rough arrangement: it may look well in front, but leaves an offset on the lingual surface that is a source of discomfort, and does not give the root any great degree of protection; yet I have seen cases where it has been worn a long time and has proved satisfactory.

FIG. 586.

Plate Tooth soldered to platinum - wire dowel or post.

Dr. Henry Weston of Philadelphia has improved upon this by so shaping the crown upon the palatal surface that a much neater operation can be made. This crown represents on its labial surface the ordinary plate tooth, the lingual or palatal surface being recessed in such a manner as to afford the largest amount of working room without impairing its strength at any point. The pins are so imbedded in the thickest part of the crown that it is not liable to be weakened by grinding. Fig. 587 represents the crown. The post or dowel is made of hard platinum or platinum and iridium, and is spear-shaped and notched on both edges to give firmness to its anchorage. The backing is of the same metal and strongly soldered to the pin. Fig. 588 represents the post. In preparing the root enlarge the canal to allow sufficient space for packing gold or amalgam securely about the pin, and with an inverted cone-burr make several retaining-points or undercuts, as shown in Fig. 589. Grind the crown to fit the root with the utmost neatness and precision. In adjusting the post to the root and crown, after punching holes in the backing to receive the pins of the porcelain crown bend the post with small flat-nosed pliers, so that when in its proper position there will be a uniform space around its entire surface. Secure the tooth and post together with a cement of rosin and wax; invest and solder. If gold is to be used as the attachment the rubber dam is indispensable. When amalgam or cement is used the rubber dam is of decided service, but may be dispensed with by those who prefer other methods of keeping out moisture. When gold is to be used, the root having been previously properly treated and everything in readiness, put upon the point of the post a pellet of phosphate or oxychloride of zinc; then press the post and crown to their exact position into and upon the root, and with a delicate but blunt-pointed instrument, thin enough to reach the end of the canal, pack the cement firmly about the post. The object in using the cement is to secure the post in its place during the first introduction of the gold. When the cement is hard close the opening of the canal about the post with a rope of bibulous paper, and attach the crown to the root and adjoining

FIG. 587. FIG. 588. FIG. 589.

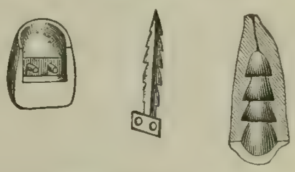
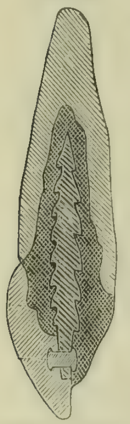


FIG. 587. Weston Crown.
FIG. 588. Weston Dowel.
FIG. 589. Root prepared to receive a Weston Crown.

teeth on either side with soft wax; see that the joints are exact in every particular, as after the next step mistakes are not easily remedied.

Paint the joint from the labial side with cement mixed to the consistency of cream. Cover the labial surfaces extending over the cutting edges of the porcelain crown and the adjoining teeth to the thickness of three-eighths of an inch with carefully-mixed impression plaster. When hardened, the plaster may be cut from the cutting edge of the crown and the wax and paper removed. Then paint the palatal side of the joint with the cream-like mixture of cement, applied with flattened pulp-canal pluggers. When this is hard the case is ready for the gold, which should be built solidly in the canal around the post and be extended so as to cover the exposed dentine and enamel and restore the natural contour of the tooth, as shown in Fig. 590. If preferred, the cement in the labial joint may be dispensed with, and the space between the crown and the root be carefully filled with gold after the removal of the plaster covering. Amalgam can be used in place of gold, either to partially fill the root or for the entire attachment: in that case proceed substantially in the same manner as for gold, except in using a trifle more cement at the point of the post, and applying more on the palatal side of the joint to prevent a dark line showing. When amalgam is used caution the patient against biting on the crown until the next day, and be careful that the articulation is entirely free.[1]

FIG. 590.



Weston Crown complete.

Dr. H. E. Dennett of Gloucester, Mass., suggests the following method of accomplishing a somewhat similar result: "First cut the crown off; then tunnel out the root by enlarging the pulp-cavity, making it very large at the orifice and smaller as it goes in, and making retaining-points at proper places. Solder a platinum post to a suitable plate tooth, the post being large where it is soldered, a gradual taper bringing it nearly to a point; then make it barbed or rough, so that it will not pull out after the tooth is set. Having prepared the root and the tooth, put on the rubber dam; fill the root to the point where the end of the post will meet it; put on the tooth and fill around the post (turning the tooth in and out and laterally as convenience requires, the post being easily bent without danger of breaking); build out to the natural form of the tooth, using first soft gold, then that which is partially adhesive, then adhesive,[2] as shown in Fig. 591.

FIG. 591.

Dennett's Method.

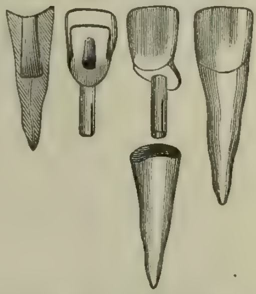
Dr. H. K. Leech of Philadelphia suggests the following somewhat novel method for firmly securing the tooth to the root: "Prepare the root with a stump corundum wheel, and drill it out three-eighths of an inch in depth and about No. 16 standard wire gauge in diameter, enlarging it at the bottom, as shown in Fig. 592. Then fill the remaining portion of the pulp-canal. Make a gold tube to fit nicely the aper-

[1] Henry Weston, Philadelphia, Pa., *Dental Cosmos*, vol. xxiv. (1882), p. 81.

[2] H. E. Dennett, Gloucester, Mass., *Dental Cosmos*, vol. xii., August, 1870, p. 399.

ture in the root about three-quarters of an inch in length, so that it can be more easily handled; adapt a plate of gold or platinum to the face of the root; cut a hole in it to correspond to the size of the tube; insert the tube in the root; place the plate in position, holding it by any suitable cement; when properly adjusted remove the tube and plate and unite them by solder; insert again in the root, and adapt a plain plate tooth with a gold backing, holding it in position with wax or cement. Then remove the tube-plate and tooth together, and solder the tooth in place, as shown in Figs. 593, 594. Then with a small separating file or saw slit the tube in two or more places for about two-thirds of its length; finish up the back of the tooth, cutting away the superfluous tubing. After this place a thin sheet of gutta-percha on the upper surface of the plate, that which is adapted to the face of the root; warm the tooth and plate and press it up against the root. The gutta-percha will thus hold the artificial crown temporarily in position, and, covering the whole face of the root, make a perfect joint. With a straight plugger fill the tube with gold- or tin-foil, condensing it so as to spread the split tube to correspond with the cavity in the root. The tooth is thus dovetailed into the cavity, so that it is almost impossible that it should become loosened, the filling of the tube making it almost equal to a solid gold wire" (Fig. 595).[1]

FIG. 592. FIG. 593. FIG. 594. FIG. 595.



Illustrating Dr. Leech's Method: FIG. 592. Section of the root. FIG. 593. Crown on lingual side. FIG. 594. Front view of crown and root. FIG. 595. The Crown complete.

Where permanency is desired it is far better to make a plate to cover the free end of the root, and better still to fit and solder to it a thin piece of plate, so as to form a rim or collar extending about three-fourths around the root, and wide enough to go a little beneath the free margin of the gum, making the plate really a cap. This gives the root all the protection practically possible, and makes a neat, smooth finish on the lingual surface.

I will now proceed to describe my method for constructing fixtures of this kind: they are not difficult to make, but require accuracy and care at every stage. They must be *made* to fit; they cannot be altered after they are finished without destroying that close contact of the root and the plate it is so desirable to maintain.

It is well to determine first whether a cap or simple plate is desired. If the root is so much broken down that the edges are below the level of the gum, we have no choice: it would be very difficult to fit a collar, and a collar made to fit low down on the root would be likely to cause more or less irritation and discomfort, so that in such cases it is best to file the edges level, cutting them away so as to allow the gum to cover the joint when the appliance is in place, and then to fit a plate to well cover the face of the root, but not to extend beyond it. If even a small portion of the walls of the root remains above the alveolar process on the lingual side, a cap can generally be made: where I decide to do so in preparing the root I leave it a little higher on that side.

[1] H. K. Leech, D. D. S., *Dental Cosmos*, vol. xxi. p. 232.

For convenience of illustration I will describe the method of constructing a crown for either of the front teeth: the same description will answer equally well for any of the six front teeth of either jaw. The bicuspid teeth require a little different treatment, which will be noticed as I proceed. I assume that the pathological conditions present have been properly and successfully treated, and that the root is in a healthy condition. This treatment should always precede any operations upon the root except such as are needful to gain access to the pulp-canal. In removing the remains of the tooth I am not favorably disposed toward the cutting forceps, believing that the judicious use of tools in the dental engine will generally prove equally efficient without those risks of injury or fracture which attend the use of forceps. If there is much tooth-substance to remove, with a disk cut in as far as may be on both the labial and lingual sides, and then with a large wheel-burr revolving in the pulp-canal cut a deep groove all around opposite to the cut previously made. This will so weaken the tooth that it is readily broken off with a small pair of root-forceps, without risk and with but little discomfort. Cut the root down nearly to the gum—but not so near as to cause it to bleed—and we are ready to fit the retaining-pin or post. If the gum is caused to bleed the blood will interfere with the preparation of the root. Then, with a tapered reamer (Talbot's is admirably suited for this purpose) enlarge the pulp-canal. I prefer this instrument to a drill when it can be used, as it not only enlarges, but also straightens and gives the canal a regular shape, and there is no danger of its going through the foramen. In enlarging the canal bear hard against the lingual side: it is desirable to have the post as far on that side as possible, so as to have it strongly attached to the plate. In some cases the porcelain tooth covers the centre of the root, and as the plate under the tooth must generally be quite thin, if the backing is soldered to the plate inside of the point where the post is soldered, the post gets no support from the backing, and its attachment is thus necessarily weak. To avoid this the upper part at least of the post should be well under or inside the backing. In preparing the post, make it of heavy gold plate—say, about one thirty-second of an inch thick: if the gold contains a little platinum, as in the alloy used for clasps, it makes a stronger appliance. It should pass into the root as far as possible. The reamer, used as a measure, will give an idea of the length required: for convenience of handling it should also project from the free end of the root at least one-fourth of an inch. Cut a wedge-shaped piece (Fig. 596) the length required: let the wide end be about one-eighth of an inch in width, and file the other end to a sharp point. It should be somewhat wider than the hole reamed in the root. Place the post, thus prepared, in the enlarged pulp-canal, so that its line of greatest diameter is parallel with the antero-posterior diameter of the root. The natural teeth on either side protecting and supporting the artificial tooth against any side pressure, this is the direction of greatest strain, and the post thus placed is in the position best fitted for resisting that strain. It will generally be found on trial that the post will fit better with one than with the

Fig. 596.

The Post.

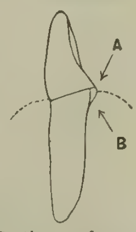
other edge front: when the best position is selected with a file make a notch in that edge of the post which is to be so placed; make the notch on the projecting portion of the post which is to be cut off, and always keep that edge to the front. It will save a great deal of trouble and confusion to make this an invariable rule in all cases. The post, being wedge-shaped and of a greater diameter than the reamer, will rest on the edges of the hole made by the reamer. With a small burr in the dental engine—the burr to be about equal in diameter to the thickness of the post—cut grooves or mortices in the labial and lingual sides of this hole (Fig. 597), making the cutting deeper on the palatine side, so as to throw the post as far in that direction as possible. Into these grooves or mortices the post will fit: if this is neatly done, when the dowel is pressed home it will hold quite firmly. These mortices effectually prevent the dowel from turning around. I prefer to let the post pass as far into the root as a root-filling ordinarily would; let it fit quite tightly in the bottom of the root and a little easy near the free surface, so that there may be no danger of its acting as a wedge to split the root. When this is done we are ready to finish preparing the root. If it is for a simple plate, cut it away until it is a little below the level of the gum all around, cutting in a little deeper on the labial side. This may be done with various shaped stones or burrs in the dental engine: they are more convenient for this purpose than the root-files formerly used.

FIG. 597.

Pulp-canal enlarged to accommodate the post.

In cutting away the labial side so as to place the joint well under the gum, a small sharp chisel does the work rapidly and neatly, with but little laceration of the gingival margin. If a cap is desired, the root is cut away on the labial side, but the palatal side is left high enough above the gum to give room for the collar. After it is properly shaped, pass around that portion the collar is to cover with a sharp, straight alveolar abscess-lancet or a cone-shaped burr in the dental engine, and cut away the projecting edge of the root, so that the collar will fit the root accurately at its lower edge. This is important. As a rule, when the face of the root is properly shaped the palatal edge is at an acute angle, and unless this is cut away before attempting to fit the collar it is probable it would either hook under so much that it would not go over the root when soldered to the plate, or instead of fitting close to the root it would press into the gum. This is shown in Fig. 598. The dotted line represents the gum; A, the face of the root; B, the portion to be cut away.

FIG. 598.



Section of an Incisor, showing a projecting point, B, which should be removed before fitting the collar.

When this is done take a piece of gold plate long enough to extend as far round the root as desired, about one-eighth of an inch wide and quite thin—say, No. 30 or 32. It may be made of platinum or pure gold; I prefer eighteen-carat plate; it is stronger and not so liable to bend. It has been suggested that a softer metal could be burnished close to the root after it was placed in position: this I have found practically unsatisfactory; it is very hard to make the burnisher bear on the lower edge of the collar when the plate is in position, and,

as it is impossible to see what is being done, the chances are, especially with so soft a metal as pure gold, that the burnisher will stretch the metal instead of working it close up to the root. Again, in cementing the plate in place the collar is apt to catch on the edge of the root instead of going over it: if it is made of a stiff metal we feel the resistance, and by changing its position can readily press it in place without injury, while a softer metal would bend, and perhaps be ruined for the purpose. If the pure gold is made heavy enough to avoid this danger, it is quite as unyielding under the burnisher as the eighteen-carat plate would be.

Before beginning to bend the strip of plate bevel the lower edge and polish it. Then, with a pair of smooth round-nosed pliers or the clasp-bender bend the plate to approximate the shape of the root, being careful to keep the bevelled side out and next the gum. While fitting the collar it is not necessary to press it into the gum each time it is tried on the root: if it is held gently against it the changes necessary can be seen as plainly as though it were pressed into position. When an imperfectly-fitted collar is pressed into place it cuts into the gum instead of slipping between the gum and the root, and is quite painful to the patient—far more so than after it is neatly fitted. Always be careful to make the lower edge fit closely and accurately, and see that it rests firmly against the root: make it fit tightly enough to hold in place by itself, without the help of an instrument, while taking the impression, but do not make it "spring" on or clasp the root tightly: if it does, it will spring together after it is removed, and, being soldered in that position, will prove too small to go over the root—a mishap that would probably make it necessary to do the work over again.

It often happens that while the lower edge of the collar fits accurately the upper edge does not. This, if the maladaptation is slight, is not always a matter of importance, and is sometimes unavoidable on account of the shape of the root. Let the collar extend just under the free margin of the gum, so that the gum shall cover and hide its lower edge, but do not let it go beyond this point. There is nothing gained by extending it farther, and there is great danger of causing irritation by so doing. After the post and collar are fitted the impression may be taken and the remainder of the work be done on the cast. I think it better, however, before doing so, to also fit the plate to the root and solder it to the post; it takes but a few moments, and can be made more accurately. I prefer to make the plate of either platinum or pure gold, about the same thickness as the collar. Select a piece large enough for the purpose, punch a hole through it that will admit the end of the post, and drive the post through it about as far as it goes into the root; the plate may rest on a piece of wood with a hole in it for the post to pass through while doing this. It will save trouble to make the post fit tightly: this it usually does if after driving it in it is removed and the burr on the under side of the plate is burnished down, thus slightly closing the hole. Then pass the post through the hole in the plate and fit it on the root; be sure that the post goes in the root all the way. With a burnisher make the plate fit the root as accurately as possible, especially around the post. Carefully remove the post

and the plate without disturbing their relative positions; lay them on the soldering charcoal, and, adding a little plaster to hold them, solder the post and plate together. If the post fits tightly, the plaster may be dispensed with, but there is always a risk in doing so, the solder in flowing is so apt to cause a slight movement in the small pieces of metal to be joined.

After soldering place the appliance on the root, press it well home, and burnish the plate down to position: cut off all portions that project, and in front leave about a line of the root exposed, so that the edge of the tooth shall rest directly upon the root. When the plate fits adjust the collar and see that the plate does not prevent its properly fitting the root.

Greater accuracy is secured by uniting the plate and collar in the following manner: place the plate and the collar in position, building over them a little plaster so as to hold them together, and yet not encroaching on the adjoining teeth so as to prevent their removal. When the plaster is hard, remove the appliance carefully, and immediately invest it in a mixture of one part plaster and two of sand, and solder the collar to the plate, thus completing the cap before taking the impression. By this method we avoid the risk of changing the relative positions of the collar and plate attending their removal and replacement on the cast. We are now ready to take the impression.

Plaster is the only material suitable for taking impressions for crowns mounted in this way: it has the advantage of not displacing the parts to which it is applied, and of holding them rigidly in their relative positions when it is removed. In some cases, where the face of the root is much below the gum or the space between the teeth narrow, especially if we intend fitting the plate on the cast, it is well to pack a little gutta-percha (either "base-plate" or that used for fillings) directly on the face of the root, and finish the impression with plaster: it sometimes gives a better impression of the face of the root, because as it is pressed up it pushes the gum aside, while plaster in such cases is apt to fail to reach the edge of the root on account of the saliva or blood often found there, and which cannot be kept away long enough for the impression to be taken: even if the plaster reaches all points on the face of the root, the presence of blood or saliva may prevent the sharp edges of the impression from hardening. In either case the edges of the root would not be as sharply defined in the impression as they should be in order to ensure a close and accurate fit of the plate.

In all cases the post must be fitted to the root, and be in place when the impression is taken, to secure accurate results. If a collar is used, it also must be fitted to the root and be in place. In taking the impression a cup is not used: the plaster is built up over the root and over one or two teeth adjoining it on each side. I recommend the following method: Place within convenient reach, on the extension table, a saucer containing sufficient dry plaster, a dental syringe filled with water, a spatula, and several small tufts of cotton. After arranging everything in the mouth and drying the parts to be covered by the impression, inject a little water in the plaster: mix and carry to the

mouth with the spatula just sufficient to secure the collar, if one is used, and to cover the root, and put it in place with a tuft of cotton held in the tweezers, being careful not to displace the post or collar in doing so. When this part of the impression has slightly set add more plaster, working it in place until the space is filled and the teeth on each side are covered to the depth of about one-eighth of an inch. It is generally best to include two teeth on each side of the space, so as to have a good guide as to exact position in arranging the porcelain crown. If the impression is an accurate one, it is seldom necessary to try the tooth in the mouth before finishing. If a quick-setting plaster is used, it will probably become too hard to make the impression in the manner directed without more than one mixing; therefore after the first addition we add more water and mix a little more plaster, and so on until the impression is complete; having the water in the syringe, this can be readily done with one hand. After the plaster has set proceed to remove it; it should be allowed to become much harder than an ordinary impression. It usually breaks into a number of pieces, which must be carefully preserved. To remove it place a finger and thumb on either side and gently make pressure as though to rock it sideways. This after a few movements will often so loosen it that it will come off intact. Sometimes it is necessary to break it away over the teeth, and if the dental interspace is much wider at the gum than at the cutting edges it may be necessary to so split the plaster in the space that it can be taken out either on the labial or palatal side. This, however, is best avoided whenever possible, for, while the plaster can be put together quite accurately, there is, apart from the danger of displacing the post or the collar, a risk that there may be a change in the relative position of the pieces—so slight, perhaps, as to be of no moment had it occurred in any other part of the impression, but a serious matter here. If the dowel should be loosened in the impression, it is very important to replace it in its exact position; if there is any doubt of this, it is far better to take a new impression.

After the impression is taken place a piece of wax in the interspace and let the patient close the teeth, so as to get the "bite" or articulation. It is better not to have the wax soft, but just as hard as it may be without making it impossible for the patient to bite into it: it then gives a sharper impression. Be sure in taking the bite that the teeth are tightly and accurately closed, and while examining the mouth see if there is any risk that the opposing teeth will encroach more on the space during the movements of mastication than they do when the teeth are brought tightly together. In many cases we find the opposing teeth encroach abnormally upon the space to be occupied by the artificial crown, this being due in some cases to the fact that the tooth we desire to replace has been missing from the arch a long time, or to its having occupied an abnormal position. No doubt in many cases the necessity for artificial crowns is due mainly to an abnormal position either of the lost tooth, weakened by caries, or of its opposing tooth, the result in either case being the throwing of a strain greater than it can bear upon the walls of the weaker tooth. It is always best to allow a little "play"

when fitting a crown to the articulating model, as it usually happens, from causes we cannot always control, that the natural teeth bite down or out a little more than is shown on the cast: it is probable, too, that in cementing the finished tooth in place in the mouth its position may be slightly changed or that it may not go into absolute contact with the root. It is best to provide for these possible mishaps, especially when we consider how difficult it will be to make any change after the case is done: as a rule, it is best not to let the artificial crown touch the opposing tooth; if it does, it will usually be loosened in a short time.

After taking the articulation select a shade tooth—that is, a porcelain tooth as nearly the shade of the natural teeth as possible—to serve as a guide in selecting the tooth to be used. It is well to keep on hand a number of teeth of various shades, shapes, and character to be used for this purpose; better, perhaps, to keep a stock of teeth suitable for these cases from which a tooth may be selected at once; it will frequently save time and trouble. In selecting a shade it is well to remember that for young patients the tooth should be slightly darker or have a trifle more of a yellow tinge than the natural teeth, to allow for the gradual change in color that nearly always takes place in advancing from youth to middle or old age. When selecting the shade tooth notice whether a darker or lighter color, or a gray, yellow, or blue tinge, etc., will be least objectionable in case the shade tooth cannot be accurately matched, and also notice the shape, character, and other peculiarities of the natural teeth it is desirable the porcelain tooth should possess. The presence of fillings or decay or discoloration in the adjoining teeth should also be noted, and a tooth selected that will harmonize with its immediate surroundings; at the same time, when the difference between one or both of the adjoining teeth and their fellows is excessive and verging upon the unsightly, especially if from their condition it is probable that they may not long remain *in situ*, it is better to select a tooth that will measurably harmonize with the normal teeth rather than perpetuate an objectionable defect. Our aim should be to have nothing about the tooth to attract attention; and I find that if the tooth is a little darker in shade than natural (unless the natural teeth are unusually dark), it is far less noticeable than a shade the same degree lighter would be; it also anticipates the marked change just referred to that usually takes place in the color of the teeth as age advances: this change is more marked, perhaps, in passing from the age of twenty to thirty or thirty-five than at any subsequent period, although it continues through life.

In selecting the teeth we may remember that if the tooth is a thin one of light shade and translucent body, it will look perceptibly darker when the backing is soldered to it, while a darker or thicker tooth will not be noticeably changed. It is usually best to select a number of teeth slightly varying in shade, size, and character, and examine them in the mouth, holding them in place with the tweezers or a piece of yellow wax. It frequently happens that two moulds or two shades of teeth that seem nearly alike out of the mouth will look very different when placed in the position they are to occupy in the mouth.

The artistic success of this operation largely depends upon accurately matching the style, character, and shade of the natural teeth.

It is always best at this stage to let the root rest a few days or a week before inserting the tooth. To prevent the gum growing over the root in the interval select a carpet tack with a large head: file the shank thin enough to go into the root easily, and bend it, if need be, so that the head will lie flat on the root. After passing up the canal a little cotton moistened with creasote or other dressing, imbed the tack in softened gutta-percha, the same as that used for fillings, and press it in place in the root, moulding the gutta-percha so that it shall entirely cover the head of the tack and extend a little beyond the root all round. If there are teeth on each side, let it rest hard against them. This not only prevents the gum from growing over the root, but pushes it back from the root, so that when the tooth is inserted we have a better chance of securing a good joint. It also completely closes the pulp-canal, and enables us to test the healthy condition of its walls and of the root-membrane. The tack is easily removed by grasping the head with a pair of root-forceps warmed to soften the gutta-percha, and gently drawing it out with a slight rotating motion.

In putting the impression together place the pieces in position and drop a little hard wax (a mixture of beeswax and rosin) over the joint on the outside—not on the broken surfaces that are to come together: nothing whatever should be placed on these surfaces in repairing an impression, as, no matter how carefully it is done or how little cement may be used, the joint is kept apart; then, too, in putting an impression together it often happens that after several pieces have been united it becomes necessary to separate them in order to get another piece in place. This is easily done if held by a little wax on the outside, but if the pieces are firmly united by cement between the fractured surfaces, the process is rendered far more difficult and uncertain. Any small pieces which belong entirely to the inside of the impression and do not reach to the outside should be placed in position and a little thin varnish dropped over them. When an impression is badly broken it is best to oil or varnish the outside, and then imbed it in plaster before making the cast; this avoids any risk of its coming apart while the cast is being run. The oiling of the outer surface of the impression makes less difficult the removal of the added plaster, as this will not unite to oiled surfaces, and after setting can be readily taken off, when the impression will be found intact and be readily parted from the cast, owing to its previous fracture. It is sometimes desirable to place a little yellow wax on the outside of the collar to permit its more ready removal after the cast is made.

Before making the cast I prefer to build a wall or ring of soft wax around the impression to confine the plaster and to give proper form to the cast, allowing it to extend about a half or three-fourths of an inch above the edge of the impression. This takes but little time to adjust, and is far neater than allowing the plaster to run over the outside of the impression: when this is removed after the cast is hard the impression is fully exposed, and the risk of injuring the cast while removing the surplus plaster avoided.

Before running the plaster the impression should first be prepared upon its inner surface to prevent the plaster of the cast from uniting with it. Lard or sweet oil may be used for this purpose, applying with a camel's-hair pencil several thin uniform coats, allowing each coat to dry or soak in before applying the next, and adding a little rouge to the last coat to color the surface of the impression, so as to more readily distinguish the line of separation when removing it from the cast. A coat of thin shellac varnish, followed by one or two thin uniform coats of sandarac varnish, is equally effective and rather more cleanly, giving a harder and smoother surface to the plaster cast than when oil is used. In using either oil or varnish it must not be applied so freely as to fill up the more dependent portions of the impression.

Immediately before running the plaster fill the impression with clean water, allowing it to remain a few moments to moisten the surface, pouring it out, and by shaking or the use of bibulous paper removing the drops that are disposed to cling to the surface. Mix the first portion of plaster to about the consistency of thick cream, beating it up well before pouring it into the impression, and adding a little at a time until the imprints of the teeth are filled, shaking it down thoroughly after each addition: after the body of the impression is filled place a piece of glass over it, pressing it down until it rests upon the wax ring: it may now be inverted and allowed to rest upon the glass until hard.

Plaster can be more thoroughly and quickly mixed in a cup than in a saucer; thoroughly beaten up in a cup with a spoon or spatula to the consistency of thick cream, it makes a much harder cast than would a thicker batter mixed in a saucer, owing no doubt to the more thorough manner in which the water is mixed with it.

When the plaster is thoroughly hard remove the wax ring and proceed to remove the impression, breaking or cutting it away carefully, so as not to break or mar the cast. After the impression is removed trim the cast to a proper shape, and before the post is at all disturbed cut away from the bottom of the cast so as to just expose the point of the post: the object of this is to get the exact length of the part in the root. The cast should be cut or scraped away, leaving a flat surface just over the post and exactly level with the point of it; we can then, at subsequent stages of the work, easily see whether the post is in place or not. It also gives a convenient method of removing it from the cast when the plate or tooth is cemented preparatory to soldering: a point placed on the end of the post will push it off without the slightest risk of disturbing the relative positions of the various pieces in the appliance.

After the cast is prepared carefully withdraw the post, lay it aside, and proceed to make the plate, if that was not done before the impression was taken. If the case is to have a collar, the plate may be of platinum thin enough to burnish down to the root; if a collar is not to be used, I much prefer to make the plate of gold. If the thin platinum is used with the intention of fusing gold or solder over it to give it strength, it will seldom secure a neat result. No matter how carefully the plate has been fitted, the shape is usually changed after the gold has been fused over it: the edges are apt to turn up; it is quite

difficult to get it of an even thickness and to get the edges of the plate thick enough to finish up well; when the case is done the edges are usually jagged and uneven, and do not accurately follow the outline of the root.

If a thin platinum plate is to be made, select a piece large enough for the purpose and thin enough to easily burnish down to the model of the root, and proceed to make the plate in substantially the same manner it would have been made if fitted to the mouth as previously directed. Place the plate on the cast, and with a hammer gently tap the post until its point comes just level with the place cut from the bottom of the cast, thus returning it to the same position it occupied before it was withdrawn. Remove the post and plate carefully from the cast, making sure that their relative positions are not changed; lay them on the charcoal, and place a little plaster at the edge of the plate and at each end of the post, so as to prevent movement during soldering. Use as little solder as possible; do not let it run over the plate—a piece the size of a grain of sand is usually enough; all that is necessary is to tack them together, but it is better to make the solder run all around the post. If too much solder is used it will run over the plate, and make it so stiff that it cannot be adapted to the model. When the soldering has been completed and the borax has been removed by acid, place post and plate on the cast and burnish the plate down to the cast at all points; then cut or file it so that it will fit inside the collar and come within a line or two of the front edge of the root. When this is done cut off the extra length of dowel not quite close to the plate; place the collar in position and cement them together with shellac. It is very important to have a hard and strong cement; the collar often hooks in slightly; it is better on this account that the cement should rather break than bend.

Shellac answers the purpose in a majority of cases: if it should break it can usually be placed together without risk of change. To remove the appliance from the cast, place a small blunt point against the post (where it is exposed at the bottom of the cast) and push it off. In soldering the plate and collar it is best to invest in plaster and sand—letting the sand be largely in excess; two parts sand to one of plaster—and heat it up over a gas-jet or in the furnace, as would be done in soldering teeth. In making a gold plate the manipulation is much the same. It is not needful to make dies if the plate can with the hammer or pliers be bent to fit neatly. In soldering the collar use as little solder as possible, so that none shall run inside and interfere with the fit either of the plate or collar upon the root; at the same time strengthen the solder around the post if it should need it. When done place it on the cast to see that the fit is not changed: then remove the front edge of the plate until a line or two of the root is exposed, making the extreme edge quite thin, and filing the plate smooth and even as far as it will be covered by the tooth. The bite or articulation having been previously made, we are ready to select and fit the tooth. Whenever possible select a straight-pin tooth. It is far better to have straight pins, even if the lower pin is close down to the plate; and as it is desirable to have the backing between the porcelain tooth

and the articulating tooth, it is very seldom that they cannot be used. With cross-pins there is much more leverage, and, the pins being on a line, allows a little working of the tooth, which soon breaks them off.

While setting artificial crowns by this or similar methods there is ample opportunity for the operator to combine his mechanical and artistic skill. Within ample limits, without regard to the position of the root or the direction or position of the post, the tooth may be placed in any desired position. Quite frequently a slight change in the alignment of the tooth enables it to resist or to avoid an otherwise injurious strain, and at the same time improves its appearance quite as much as it increases its usefulness and permanency.

Placing the tooth irregularly, with one edge more prominent or overlapping the adjoining tooth, may give it a very natural expression, and at the same time allow the opposing tooth to close without striking it; in other cases making the tooth a trifle short or slanting forward or leaning in or out, or changing the shape of the cutting edge, etc., may give an equally pleasing effect. These changes are not to be made haphazard or as a mere matter of form, but always with some definite object in view.

Fitting an artificial crown calls for more care than is required in arranging a tooth upon a plate: as it is intended to be a fixture in the mouth, cleanliness requires that the joint between the tooth and the plate and root shall be as close as possible. First file the plate away, bevelling it from its upper surface to a thin edge, so that the labial aspect of the tooth may rest upon the root and yet have a solid bearing upon the plate.

In grinding use a small stone, and endeavor to make the tooth fit not only at the edges, but solidly at all points. In difficult cases the surface to be fitted may be covered with rouge or other pigment, so as to mark upon the crown the points of contact.

If there is any special difficulty, such as a peculiar slant or position of the teeth or a very close bite, it is best to test in the mouth the accuracy of the adjustment. Before doing this cement the tooth in place with shellac instead of the usual rosin and wax. When the tooth is satisfactorily adjusted invest and proceed to make the backing, solder, and finish the case in the usual way.

It is sometimes desirable to build up the palatal surface to conform somewhat to the size and shape of the natural teeth. This can be readily done when soldering, either by building up solidly or by fitting a piece of gold and placing it in position after the backing is soldered to the plate, and soldering it around the edges. Sometimes this extra piece is swaged up to contour with zinc dies made from a natural tooth as nearly as may be the size of the one to be replaced. When the natural teeth are quite thick, and when a tooth with a simple backing would stand in very much from the line of the other teeth on the palatal surface, the addition of this extra piece adds very much to the patient's comfort.

The tooth being finished, it is placed in position in the mouth: if the work has been done accurately it will fit perfectly, but sometimes a

slight change will take place in soldering. It may bear too hard at some point, or a little solder may have run under the plate, etc., or the backing may be too thick to allow the opposing tooth to close without striking it. Before proceeding to make any changes, however, see that the root is entirely clear—that no cotton or particles of gutta-percha are left in it to prevent the post from going into place. This is a mishap which is liable to occur, and may pass unnoticed unless attention is directed to it. It is often quite difficult to see where the fault is in cases which do not go directly in place, and recourse may be had to various expedients to assist in finding it. A little yellow wax may be placed under the plate, and the appliance be placed in position and firmly pressed against the root, or tracing-paper or various pigments may be used in like manner. The wax I have usually found more reliable and satisfactory; it gives a good idea of the accuracy with which the plate fits the root at all points, while the other methods only indicate the points of contact. In adjusting the articulation tracing-paper or paper coated with lampblack and some fatty substance, such as lard or tallow or a mixture of lard and white wax, is often of great assistance in indicating the more prominent points. The parts to which it is applied should be wiped quite dry to obtain good results.

It is very important to have the articulation clear, especially with the front teeth.

When the fit has been found satisfactory both tooth and root are ready for the final steps in the process. It is desirable to leave the final preparation of these until the operation has reached this stage, not only to avoid the extra trouble the undercuts in the root and the barbs on the post would cause in trying in the tooth and in changing the dressing in the root, but also to keep the barbs sharp and unbroken. We may bear in mind that to hold in place well there must be some little body of cement between the plate and the root: if gutta-percha is used, the root should be made slightly concave in the centre, especially if the plate has no collar around it, for if the plate and root are in nearly absolute contact at all points, the gutta-percha will after a little while work out from between them, leaving a bad joint. The same effect will follow the use of the oxychloride or the zinc-phosphate cement: the thin layer will soon be broken up and disintegrated. But if the layer of cement is considerably thicker at the middle than at the edges, as it will be when the face of the root has been made concave, it is held far more securely, and seldom fails to preserve an accurate and cleanly joint. I prefer gutta-percha for the packing or cement, selecting a grade that softens at a moderate heat. When too much heat is required to soften it, it usually chills so quickly as to render it difficult to get the fixture in place; and the gutta-percha is apt to strip from the post instead of going up into the root with it: not only is the operation thus made painful by excess of heat, but it also becomes uncertain, because the gutta-percha does not flow and fill thoroughly the space around the post.

The objections to the zinc cements are that they are liable to wash out in a comparatively short time, and are difficult to work on account of their rapid setting; also, that in case of an accident requiring the post to be withdrawn from the root there is no way of breaking up or softening

the cement: its removal is therefore difficult, and the force required dangerous to the root and liable to seriously injure and mutilate the plate. In exceptional cases, where the post is short or the strain tending to rotate the tooth unusually severe, or where from any cause the slight force needed to press the gutta-percha in place is objectionable, the zinc cements may be used to advantage. Amalgam is often recommended, but in addition to the objections urged against the zinc cements, which apply with equal force to this, there is the disadvantage of its turning dark and making an unsightly joint; and as it takes some time for it to become hard, perhaps several hours, there is also great danger that while the amalgam is still soft the post may become disturbed and loosened by the occlusion of the opposing teeth or from other causes. And, again, in order to have amalgam plastic enough for the purpose so much mercury is used that with most alloys there is considerable shrinkage, and a risk that the mercury will unite with the solder and after a time cause it to break away. Even if the post and plate are made of platinum, there is more or less solder that usually contains metals with which mercury will unite. A good quality of gutta-percha leaves but little to be desired. If the plate is fitted as it should be, there is but little difficulty of getting it in place, with the gutta-percha thoroughly filling all the space between it and the root: it is well protected from wear and not liable to disintegrate, and may be expected to last at least as long as any available cement.

In using gutta-percha I find a water-bath a decided advantage; by its use the gutta-percha can be kept warm long enough to soften throughout the mass without any risk of overheating. I am inclined to think that passing it through the naked flame does not secure the best results. There is always danger of its becoming overheated: if this is avoided, there still remains the fact that the outside is softer than the centre, and when it is placed in the cavity it does not pack as solidly as though it were softened evenly throughout. In setting crowns I have found this an important matter. If the gutta-percha around the post is not thoroughly softened, and the post and plate are not hot enough to keep it plastic until it is well in place, the chances are that in addition to the difficulty of pressing the tooth accurately into position the gutta-percha will be stripped from the post and but imperfectly fill the canal. It will neither take firm hold of the barbs on the post nor run into the retaining-grooves of the root, and in a short time will loosen and fall out. It has been suggested to avoid this by dipping it into chloroform just before placing it in position. I think this a mistaken practice; it makes the outside soft and adhesive, so that it readily sticks to a dry surface, and also acts as a lubricant. It is pressed into place with less force than if it had not been used; but, on the other hand, it dissolves the surface and really coats it with a saturated solution of gutta-percha in chloroform; indeed, it penetrates to some little depth and renders almost the entire packing quite soft. It is this softened gutta-percha that comes in contact with the walls of the canal and fills the retaining-grooves. When the chloroform evaporates, as it will in a short time, those portions on which the permanency of the operation depends so much are not nearly so hard and dense as

they otherwise would be. I object to the use of such substances as varnish of various kinds, creasote, etc., as being useless if not injurious in all cases.

It is necessary to have the cavity perfectly dry and as clean as possible: washing with absolute alcohol assists in securing both results, but this is not essential; warm water and bibulous paper will usually prove quite sufficient.

When the crown and plate are satisfactorily fitted remove them from the root, wipe perfectly dry, and with a sharp narrow-bladed knife or chisel cut long barbs on the four corners of the post: do not simply roughen it, but cut long, strong barbs pointing toward the plate—say, from four to six on each corner. Then place around the post and under the plate a little more gutta-percha, previously softened over the water-bath, than is judged sufficient to fill the space between the appliance and the root: it is always best to have a little excess to press out. Mould this with the fingers to a close adaptation to the post and to about the shape of the cavity in the root, letting it extend a little beyond the point of the post, so that when it is placed in the root a little of the cement will be carried in advance of it. If the crown has a collar, carefully keep the gutta-percha away from the edge, or it will be difficult to see whether the collar is going over the root properly in placing it in position. Having applied the gutta-percha, place the tooth over the water-bath to keep the cement soft, and also to warm up the tooth and plate while the root is being prepared.

Make the surface of the root slightly concave, if that has not already been done, and then with a small wheel in the dental engine, held as shown in Fig. 599, cut several slight recesses or retaining-grooves. This may be done with a short-bladed excavator if preferred. Without these cuts there would be danger of the gutta-percha coming out, as the cavity in the root is conical in shape: the cuts need not be very deep, however, and one on each side is usually sufficient. Then with the syringe rinse out the cavity with warm water, and the root is ready.

Fig. 599.

Manner of forming retaining-grooves in the root.

Place within convenient reach a supply of bibulous paper loosely rolled, so that it will easily pass up the root. A special instrument will be needed to press the tooth up into position: a piece of hard wood shaped somewhat like a file-handle—the shank end made square with a V-shaped groove in the end—will answer. As the tooth when placed in position is quite warm, or rather hot, this instrument should not be faced with anything the heat will affect: a covering of leather may make it less liable to slip or to injure the tooth. The force needed is not very great: it should be a steady pressure when gutta-percha is used; the mallet is inadmissible. A small pair of light straight forceps with narrow beaks will be found useful to hold the tooth when warming it just before inserting it in the root. When all is ready place a napkin around the root (it is rarely that the rubber dam can be used, but when possible it is far better) and carefully dry it and the surrounding parts: grasp the tooth lightly in the forceps, taking hold of the proximal surfaces (if the tooth is warm

first warm the forceps). Carefully pass the tooth over the flame of the lamp to thoroughly heat it, the object being to heat the tooth and plate, so that when the gutta-percha becomes chilled by contact with the root, the heat from the post and plate will keep it plastic until the tooth is well in place. When heating it the flame must not come in contact with the gutta-percha until the last moment; then it may be quickly passed through the flame and be immediately inserted in the root. The forceps are used only to carry the tooth to the root and partly insert it. Then with the fingers or the instrument previously mentioned quickly press it well in place, so directing the pressure that the collar, if one is used, will properly pass over the root. In order that it should do so it is sometimes best to at first keep the tooth well inside the arch until the end of the root has entered the collar; then quickly press it forward. It is quite important to guide the tooth so that its position will not need any change after it is in contact with the root. The probability is that any change then will disturb the gutta-percha and impair its stability. To avoid this, when the tooth is within the thickness of a card-board of being in place carefully examine its position and make any needed change before pressing it firmly in place. When it is finally in place hold it firmly for a few minutes to allow the gutta-percha to chill, or aid the process by injecting upon it a little cold water. With the grade of gutta-percha used for this purpose there is, if the pressure is immediately released, a tendency to displacement, the tooth being slightly pushed out by the resiliency of the cement.

It may happen—especially at the inner edge of the tooth where it sits on the plate—that there may be a little space between the plate and the root. At these places with a blunt plugger pack the gutta-percha in while waiting for it to cool. When it is thoroughly cool, not before, take a thin flat point (Taft's spring-temper plug-finishing files are admirable for this purpose; the end is just the right shape and size; I have used them for years in preference to anything else: being small and delicate, they require frequent reheating); make it quite hot, and with quick, short strokes cut off the surplus close to the tooth and root. In doing this make a clean cut: if the instrument is cool there is a tendency to draw the gutta-percha from under the plate; this is to be avoided. It has been recommended to slightly oil the instrument or to moisten it with chloroform, etc. I cannot approve of either practice: both leave the edge we wish to be solid and firm, soft and in a condition to readily disintegrate. If care is used the instrument need not touch the gum-tissue, and it may be used hot enough to make a clean cut without inconvenience to the patient. It is desirable to see the patient several weeks after the tooth is inserted, to make sure that none of the gutta-percha extends beyond the joint. It often happens that a thin film of it passes down between the root and the gum, in a position where it can scarcely be seen or removed when the tooth is inserted; but after a time it curls up and causes more or less irritation. At times the irritation from this cause is quite severe, and no doubt valuable roots with crowns attached have been extracted, after the usual treatment has been tried in vain, without the real cause being suspected. Whenever irritation sets in a few days after inserting

an artificial crown in this way, carefully examine with a delicate long-bladed excavator that will reach below the plate or below the collar, passing it under the free edge of the gum all around. It is surprising what large pieces, comparatively, may be found and removed in cases where the operator was sure none had been left when the tooth was inserted.

In all cases it is better to have too much than too little gutta-percha. If there is not enough, it is difficult to add more, especially where the root cannot be kept dry or where the gum is bleeding. If there is too much, the tooth is readily withdrawn and a little cut away. In difficult cases, with restless patients, the tooth may have to be withdrawn and reheated several times.

Of course in making the tooth hot due regard must be had to the patient's feelings: as a rule, the idea that the tooth is to pass directly from the flame to the mouth excites more fear than the real pain occasioned would warrant. Until the tooth is nearly in place it does not come in contact with very sensitive tissues, and by that time, as a rule, it has cooled so as not to be painful. If patients will allow the tooth to be hot enough to keep the gutta-percha quite plastic, we get far better results. In this, as in other things where we cannot do as we would like, we must do the best we can. A great deal may be accomplished by gentleness, firmness, and management properly used and combined. There is a great deal of difference in the gutta-percha: some specimens require a great deal more heat than others; some are far more plastic, and will "flow" more readily at the same heat, than other samples will. What is needed is a material which softens, but does not become pasty, at a moderate heat—which softens readily through and through, and not just on the surface in contact with the heat, and which when soft readily flows and does not chill too quickly.

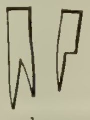
If a cement is preferred, the phosphate of zinc is rather better than the oxychloride. It is more adhesive, rather less injured by contact of moisture before it has set, and is less irritating. The cautions to be observed in its use are to work promptly, to get the tooth in place before it begins to set, to see that it goes up and fills the root, and to hold the tooth firmly, without the slightest movement, until it is well set. These cements are apt to strip from the post, so that although an excess may have been used, instead of going into the root with the post they are left at the orifice of the cavity, a very imperfect operation being the result. It is best to have a grade that sets slowly, and to mix it to not too stiff a consistence. Before inserting the crown place a little of the cement in the root, pressing it well down with a tuft of cotton. These manipulations must be done quickly: if the cement begins to set nothing can be done but to remove it and try again. The phosphate of zinc can be made to set more slowly by placing the slab on which it is to be mixed and the bottle of acid solution on ice, so as to get them quite cold. In warm weather this had better be done in all but the most simple cases. If the tooth should fail to go into place, there is frequently a great deal of trouble in removing the cement from the root, so that it saves time to take all

possible precaution to prevent a mishap. After the cement is hard the same precautions as to the removal of all the cement that has pressed out are to be observed as when gutta-percha is used.

In the description given I have, as a matter of convenience, selected one of the front teeth: there is no difficulty in replacing any of the teeth by substantially the same method. It is a question whether it is worth while to place a porcelain crown on any root back of the bicuspids unless it is particularly exposed; a gold cap is more desirable for a molar. In replacing the bicuspid teeth I generally use a cuspid tooth and build up the back part with gold. In attempting to use bicuspid teeth I find difficulty in making them strong unless they are quite long: the strain upon a tooth cemented into a root is far greater than on a tooth soldered to an ordinary plate. A bicuspid tooth cannot be fitted as neatly, neither can the joint be made as cleanly, as when a cuspid is used, on account of its resting so far over the plate. When a cuspid tooth is used the gold collar is brought well forward, so as to extend beyond the backing and rest against the proximal surfaces of the tooth, making a neat, smooth joint.

In bicuspid teeth having a single root the mode of procedure is the same as for a front tooth. In those having two roots we may elect whether to use two dowels, or cut both canals into one, or use only one canal. This must be decided by circumstances. If the root is a large one and strong, it will be simpler to make only one dowel, either cutting the two canals into one or selecting that which suits best and enlarging it. Sometimes it is best to unite them for a short distance, and then let the dowel extend down one or both roots, shaping it as shown in Fig. 600. Where the root is much compressed or divides into two it is better to use two dowels, and in reaming out the canals endeavor to make them as nearly parallel as possible. It is an advantage to do so in frail roots: it not only gives the crown a firmer support, but also effectually prevents splitting of the root. In other respects the manipulation is so much the same, and the changes to be made so readily suggest themselves, that it seems unnecessary to enter into details. In fitting the collar (if one is used) it is usually best to first trim around the palatine surface of the root, so that the collar shall not form an acute angle with the plate. It has been suggested to make the collar wide enough to form the inner cusp: this I do not approve of as a rule. In the first place, a wide collar is far more difficult to fit, and the accuracy of the fit is more difficult to ascertain. Secondly, it usually leans toward the palate, and if extended high enough to form the cusp would make the top of the tooth wider than needful, as seen in Fig. 601. I prefer, therefore, to make it narrow, and after the case is invested and the backing riveted on, to make another collar to fit upon the first, allowing it to lean, as shown in Fig. 602. This makes a much neater arrangement. After the second collar is fitted it is placed in position and secured with a little plaster, and the case soldered. The space

FIG. 600.



Dowels or posts for bifurcated roots.

FIG. 601.

FIG. 602.

Cuspid Tooth Mounted upon a Bicuspid Root, showing the incorrect and correct shape for the inner cusp.

between the collar and the backing may be filled up solid with scraps and solder, or a piece of plate bent to shape may be soldered over it. I prefer to make it solid: usually the space is not great, and there is then no danger of cutting through the cusp in finishing and articulating. In these cases make the backing quite thin and extend it above the top of the tooth.

It has been suggested to give the palatine surface of the collar a proper shape by stamping it between dies, but I think that method will be found more cumbersome and unsatisfactory than the one described. I frequently find difficulty in selecting cuspid teeth of the right shape and small enough for these cases. They are generally too flat, and have not the well-rounded contour belonging to the bicuspids. I also insist on having straight pins, a long experience having proved them to be far more reliable. I see no advantage in cross-pins where the backing is brought well up to the cutting edge, as it always should be.

Before dismissing the case as finished carefully examine the articulation and see that the tooth does not come in forcible contact with the opposing tooth. Do not be satisfied with simply asking the patient to close the teeth, but examine the cutting edges of the surrounding teeth, and note any points that are worn, and by repeated trials get the patient to so close the teeth that these points come in contact. Make sure that the new tooth is entirely free in all possible positions of the jaw: it is not uncommon for a tooth to be entirely free when the teeth are simply closed, and yet to strike very hard during mastication—so hard that no matter how firmly fixed it would soon be displaced. The force, too, might cause severe irritation, or even split the root, so that it is quite important to note carefully the little facets worn during mastication, as they unerringly point out the various positions the jaws habitually assume in that act.

In adjusting the articulation sometimes cutting away a little of the opposing tooth will relieve the undue pressure more than would the removal of a larger amount of material from the new tooth: by this procedure too the natural tooth may be placed in a more desirable relative position.

The method I have endeavored to describe in detail makes a strong and durable operation, giving perhaps the maximum of firmness of attachment to and protection of the root, with facility of placing the tooth in the best possible position. With a little practice, if care is taken that each step shall be accurately done, the time and labor are no more than those required for less desirable methods. Where many crowns are set time is saved by having the posts ready prepared and the material for the plate and collars always on hand. It does not take long after the root is in a healthy condition to prepare it for the tooth, to fit the post, plate, and collar, and to take the impression and articulation. This is readily done at one sitting; and I find it advantageous to also have the tooth selected and fit it in place in the mouth while preparing the root: we can often obtain a better effect by thus fitting the tooth and root to each other than by depending entirely upon a cast. It is rarely necessary to try the tooth in: if the cast is accurate and

care has been taken not to mutilate it, the case can be finished with confidence that it will fit in the mouth as neatly as it does on the cast, and nothing will be needed at the next sitting but to cement it in place.

Several methods have been suggested, differing from the one described in the manner of construction, but giving substantially the same results. Dr. J. L. Williams prefers a ferrule or band encircling the root, instead of the collar. This gives almost absolute immunity from splitting of the root, but is objectionable when applied to the anterior teeth, on account of the conspicuousness of the band. It may be partly concealed for a time by bevelling the labial surface of the root, but the natural tendency of the gum to recede soon exposes its entire width ; and, again, the joint between the cap and the tooth is fully exposed, and, however neatly made, is liable to darken and become unsightly. There are cases where it may be applied with advantage, but the objections noted and the increased difficulty of construction limit its usefulness. Dr. Williams prefers pure gold, No. 34, for the cap, and a square piece of platinum and iridium alloy for the dowel.

The method of Dr. Wilbur F. Litch for forming collar crowns was first published in the *Dental Cosmos*, vol. xxv. p. 449, September, 1883, and the paper, after revision by the author, is here in part reproduced :

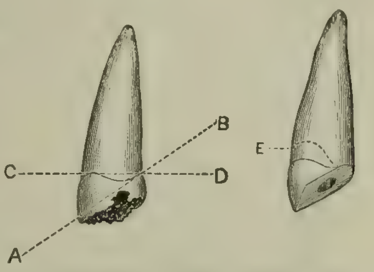
"The Collar Crown.

"The process to be described reduces destruction of tooth-substance to the minimum. Instead of cutting the palatine wall of the tooth down to the gum-margin, the greater portion of it is carefully conserved, its presence, while not indispensable to a successful result, being in the highest degree desirable. How much of this portion of the tooth can be retained will depend upon the nature of the occlusion.

"In Fig. 603 the dotted line from C to D represents the point to which the tooth is cut away in the older methods of 'pivoting ;' the dotted line from A to B, the line of abscission practised by the writer.

"As will be seen by reference to Fig. 604, the face of the tooth thus prepared presents a gradual slope from the palatal surface to the labio-cervical margin. At the latter margin the root should be cut down with suitable burrs, etc. to a point a little beneath the edge of the gum, in order that the porcelain tooth in front may pass up under the gum-margin and the joint between root and tooth be concealed. At this point tooth-substance may be sacrificed, as it does not materially diminish the strength of the root.

Fig. 603. Fig. 604.



Lines followed in preparing the face of the root.

"The several parts employed in making the collar crown are a plain-plate porcelain tooth or facing, a platinum-iridium retaining-pin, and a backing, base-plate, and collar made either of platinum, pure gold, or twenty-two-carat gold, either metal being made in thickness about

No. 30 American gauge. When platinum is used coin gold or twenty-carat gold, alloyed with copper or silver only, should be employed as a solder and covering. Twenty-carat gold may be used as a solder when pure gold is employed, while eighteen-carat gold will solder the twenty-two-carat plate.

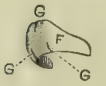
"In shaping the pulp-canal for the reception of the retaining-pin care should be taken not to weaken the root by an unnecessary enlargement of the calibre of the canal. The platinum-iridium pin need not be more than No. 14 American gauge in thickness at its point of greatest diameter, near the free surface of the root, where all the strain, if any, falls: from this point it should be made a gentle taper corresponding to the natural shape of the space it is to occupy. Half an inch in length is ample; even less will serve.

"The retaining-pin being shaped and adjusted in the root, care being taken to leave an excess in length at the free end for convenience in subsequent manipulations, the next step in the process is the making of the base-plate and its attachment to the pin. A strip of platinum or gold of suitable size is pressed upon the face of the root with broad-pointed, serrated instruments until it is in close adaptation to the surface at every point. This base-plate is allowed to *project beyond* and *overhang* the palatine portion of the root, but should not come quite to the labial edge.

"Adaptation being secured, an opening is made in the base-plate where it covers the pulp-canal, through which opening the retaining-pin may be pressed up into position in the root. Pin and base-plate are then removed from the mouth, dried, and cemented with a brittle resinous cement, and then, while the cement is still plastic and yielding from heat, placed again in position in and upon the tooth, and perfect adaptation secured. Then, while still in position in the mouth, throw upon the cement a stream of very cold water, so that it may be made brittle and incapable of bending. Then remove from the mouth and invest in a mixture of equal parts of plaster and pulverized marble, with enough water to make a thick paste. After the investment has set solder the retaining-pin and the base-plate together.

"To make the collar, a somewhat crescent-shaped piece of platinum or gold of suitable size is prepared and pressed into shape upon the palatine and palato-proximal face of the tooth; little slits may be cut in the collar with a delicate pair of scissors to make easier this adaptation. Care should be taken not to push the collar up under the gum at any point, provided the palatine wall of the tooth which had been allowed to remain standing is at all ample in height—say one-tenth of an inch; if less than this the collar may pass under the gum for a short distance, as will be shown subsequently. In the average case this collar will not quite one-half encircle the tooth.

Fig. 605.



Shape of Collar.

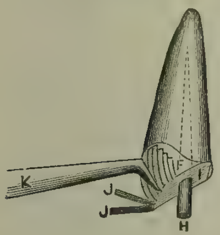
"Fig. 605 shows the collar curved to the outline of the gum-margin and shaped to the contour of the palato-proximal wall of the tooth. At G are the slits cut in the platinum to allow overlapping in shaping to contour.

"In order to strengthen the collar and facilitate its attachment to the base-plate cut a series of slits in that portion of the base-plate which has

been made to project beyond the palatine wall of the tooth, and the base-plate, with its now attached pin, being placed with the collar in position in and upon the tooth, the little strips of metal into which the overhanging edge of the base-plate has been cut are pressed, one after the other, down upon the collar and carefully moulded to its surface, so that the collar will no longer consist of a single thickness of metal, but will be reinforced by these additional thicknesses of base-plate thus pressed upon it.

"Fig. 606 shows this quite perfectly: H is the free end of the retaining-pin, which is to be cut off when the porcelain tooth is mounted. I is the base-plate, with its overhanging palatine margin cut into strips, J, which are being pressed down upon the collar, F, by the broad-surfaced and serrated instrument, K. This being accomplished, remove the several pieces from the mouth, carefully cement the collar in its proper position relative to the base-plate, which will now form a sort of matrix for it, again place in the mouth, readjust, harden the cement, remove from the mouth, invest as before, and solder the collar and base-plate together, using a considerable excess of solder for covering, so that the collar may be still further strengthened and its surface be made uniform.

FIG. 606.



Pressing the Base-plate over the Collar.

"In cementing the collar to the base-plate one precaution is imperative—namely, not to allow a film of cement to get between the collar and the tooth. If this is done and the investment poured in upon this film of cement, the latter will immediately burn out as soon as heat is applied, leaving a space between the collar and the investment into which the gold solder will flow, and thus interfere with that perfect adaptation of the appliance to the tooth which is necessary to a successful result.

"The mounting of the facing next demands attention. As already stated, a plain-plate porcelain tooth is used. This must have what are technically known as cross-pins; that is, pins placed at right angles with the long axis of the tooth. They must also be placed well up toward the cutting edge. If they are too near the neck they will inevitably be cut out in fitting the tooth to the slope of the base-plate on which it must be mounted.

"Fig. 607 shows the form of the facing and indicates the slope given it in fitting. The fitting process does not differ from that ordinarily employed with porcelain teeth; an impression may be taken and the work done on a cast, or the facing may be fitted to the mouth. In either case it is in the mouth that the finer and final adjustments as to height, contour, alignment, etc. must be perfected.

FIG. 607.

Shape of Porcelain Facing.

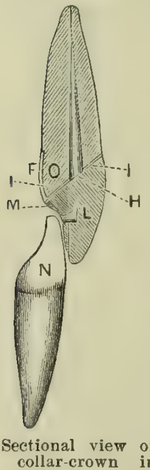
"This being done and the facing backed, tooth and base-plate are cemented together, restored to the mouth, finally adjusted, removed, and soldered as before, as much gold being flowed into the angle between the backing and the base-plate as occlusion will permit.

"This artificial crown, being properly finished and cemented into position in and upon the tooth, makes what the writer, from several years' experience in its use in a large number of cases, has found to be an appliance which will remain for an indefinite period without the slightest deviation from position and alignment, and which in many respects is almost as strong as the natural tooth, because its point of greatest resistance to pressure is placed where Nature anchors her enamel walls—namely, upon the *outside* and not upon the inside of the walls of dentine; so that in the act of occlusion the force applied by the lower incisors as they come up in position *inside* the upper incisors falls upon the *whole* thickness of the root *through the collar*, and not upon less than half its thickness through a centrally-anchored pin—a pin, too, prolonged into a lever of enormous power by its attachment to the porcelain tooth.

"In this respect there is a manifest weakness in all methods of mounting artificial crowns which depend for their stability solely upon the central pin. Ultimate failure through splitting of the root is the frequent result, and the larger and stronger and more deeply anchored the pin the more certain this result, because a large pin necessitates a large opening for its reception, and a corresponding weakening of the root, upon which the strain must ultimately fall: the lever is strengthened and the point of resistance weakened.

"The only safety for the usual form of 'pivot-tooth' is, either that the occlusion shall be slight, the root very strong, or the 'pivot' very flexible or elastic. This elasticity of the old hickory 'pivot' was one of its chief excellences: roots were much less likely to split than with a rigid, unyielding metallic pin. In cuspids or incisors, however, metallic pins, unless enormously large or thickly packed around with amalgam, will very often bend outward, thus allowing a slight displacement forward of the artificial crown, and to that extent relieving the root from strain.

Fig. 608.



Sectional view of collar-crown in position, the lower incisor in occlusion.

"Fig. 608 gives a sectional view of the collar-crown in position, the lower incisor being in occlusion. L is the porcelain facing. H is the pin attached to I, the base-plate. M is the backing and solder. N is the lower incisor, and F the collar. It is clearly evident that here the force of occlusion falls upon the palatine wall of the natural tooth at O through the collar F, and not upon the pin at the point of its attachment to the base-plate H, and through the pin upon the thin outer shell of the root.

"In cases frequently met with, where the entire crown of the tooth has been removed, the collar, as before described, can be adapted to the palatine face of the root, provided the latter be not decayed away up to the alveolar margin. Usually, however, there is a considerable space between the free edge of the root and the alveolus, and here, running up to the alveolus, the collar must be placed.

"The dotted line E in Fig. 604 indicates a collar so placed. All

the steps in the process are essentially the same as before described. Adapting the collar to the surface of the root beneath the gum is somewhat painful, but not excessively so, and in the wearing the irritation caused by its presence is very slight and transient in character, assuming, of course, that care has been taken to leave upon it a smooth, thin, and well-polished edge.

"The objection may be urged that this form of crown resists pressure only in one direction, from within outward, and does not provide for lateral pressure or pressure from the front. As a rule, the latter can occur with any force only as the result of accident, while if the crowned tooth is in normal relation with its fellows, and the artificial crown be closely fitted between them, they will fully sustain lateral force.

"Where such lateral support is wanting through isolation of the tooth, the collar must be extended into a ring or ferrule completely encircling and grasping the root, and thus affording support on all sides. The ring, however, is more troublesome to make and more painful to apply, and generally shows a line of gold in front. In the average case the simple collar gives all requisite strength.

"In mounting crowns upon bicuspid and molar roots, however, the ferrule principle is often essential to stability; especially is this true of lower bicuspids and molars; as here the forces applied in mastication are as erratic in direction as they are powerful in character, and the root must be guarded at every point against their violence.

"In fixing in position the artificial crowns just described, the writer prefers to use a gutta-percha cement adhesive in character, which will not strip from the pin when the crown is forced into position.

"The apical foramen is closed, the pulp-canal grooved and thoroughly dried, the central pin is barbed, and the pin and inside of the collar and under surface of the base-plate are thickly coated with the gutta-percha; the entire appliance is then heated to a temperature sufficient to thoroughly soften the gutta-percha, and firmly pressed up into position: the excess of gutta-percha will ooze out at all free margins, and may be subsequently removed with suitable instruments.

"A good gutta-percha cement will hold firmly in a great majority of cases, but when, as in a small lateral incisor, the retaining-pin is necessarily small and short and the collar not as ample as could be desired, an oxychloride or oxyphosphate cement, mixed thin, will be found to give greater stability. When these cements are used, however, it will be found very difficult to detach the artificial crown from the root, should it for any reason become necessary to do so; whereas a little heat will quickly soften a gutta-percha packing and permit the entire appliance to be withdrawn without difficulty."

There are various methods of mounting artificial plate teeth in natural roots, in which the dowels are used simply as a means of holding the tooth in place while gold or amalgam is packed into the root and built up to form the palatal surface of the fixture, this being mainly relied upon to support the tooth in position.

These operations, especially if done with gold, are exceedingly difficult and tedious. When we consider this in connection with the fact that

in case the porcelain crown is accidentally fractured there is no way of repairing the injury without destroying all that has been done, and redoing it, I consider them of doubtful value.

The probability of accident is always present: I therefore regard facility of repair as practically an important consideration in estimating the relative value of any method of replacing by artificial substitutes these important organs.

A SYSTEM OF AN ALL-PORCELAIN CROWN SUBSTITUTION.

By W. G. A. BONWILL, D. D. S.

No argument is needed to convince the advanced practitioner that some method is demanded whereby the thousands of good roots now sacrificed can be made permanently useful. Notwithstanding the great revolution wrought by machinery and improved appliances for filling teeth, so few are the successes that unless some plan is brought to our aid to save the remaining roots from the ravages of decay and from a want of skill and judgment by three-fourths of the dentists, we shall have little else than plates with which to meet the issue. Teeth can be saved without filling as well as by filling by some operators, but by a few only. Most of the dilemmas which all of us encounter every day are the results of bad dentistry. The plan to meet the difficulty must be one which is founded on such mechanical and physical laws that it can be safely relied upon for resisting both time and the various surrounding circumstances; one which any ordinary operator can follow, and which will be so cheap as to bring it within the reach of all; one which, if by accident the porcelain crown has been fractured, will allow of easy substitution in a few minutes without interfering again with the operation performed on the root. A crown is needed which can be obtained by every operator as easily as porcelain teeth for plate work, and can be kept in stock by him ready for any emergency, and costing but a trifle to replace; a method by which we can take any case of great irregularity, of any age and standing, and, without disturbing the root, cut off the crown and place the porcelain one in the proper curve in the arch—a result which is absolutely clean, and which will make the patient feel safer from accident than any other process of restoration.

Has any such plan been generally practised? A few have been successful by certain elaborate methods which only the exceptionally skilful could perform, and even then, when a "break-down" came, there was no alternative but to do it all over again, either at the cost of patient or operator.

Since 1871, I have been experimenting in this direction. The grand object in view was to give to the dentist at large such a made-up all-porcelain tooth as would meet almost any requirement.

My first plan—which was for the first time performed January, 1873,

but was not published until September, 1877, although frequently exhibited to the profession—of a nut with a threaded bolt planted in the root by gold-foil, did not succeed, as the safety of the whole depended on the perfect rigidity of the bolt. Gold could not be so packed, save in a few cases. Amalgam overcame this difficulty, a platinum bolt being used instead of a gold one; but this operation was practicable only to skilful mechanicians: the average dentist seemed unable to perform it.

To meet this issue the all-porcelain crown, without nut, was devised. In looking at the incisor crowns, superior and inferior, one might suppose that with so much cut away from their base and with the pinhole running entirely through the crown the strength would be impaired. So I feared when the idea was first suggested to my mind. But upon trial the strength was found entirely sufficient. The experiments were made by drilling out old-style pivot teeth with a diamond. They are now made in special moulds. . With these still greater strength is attained. The opening in the incisors is so shaped as to form a dovetail, which allows the strain outward to come high up near the cutting edge, with the base of the triangle on the labial side, and not to depend upon the palatal base for support. The bicuspids and molars are also cut out at the base, leaving little more than a shell, with undercuts for the amalgam to act as dovetails.

This method leaves no joint on the natural root and none in the crown, the operation being really an amalgam filling capped with porcelain. The hollow crown enables the operator to fit it in in a very brief time, there being but little material to grind off.

If a fracture occurs, a new crown can be placed with but little fitting on to the old amalgam base, first burring off any excess. When a case is presented *where the pulp is not exposed*, the hollow-base crown permits of so shaping the root as not to endanger the pulp, and of placing the pins on either side of the same in solid dentine. At this time I cannot conceive of a single case occurring that cannot be met by one or the other of the plans herein described and shown clearly in the cuts: the system is equally adaptable where a number of roots are in continuous circle or at intervals, or even for a full denture as the teeth one by one give way; or in making the root of a lateral bear the crown of a central, or *vice versâ*, or one or two adjoining crowns where no roots are left. Where more than one crown is needed upon one root, the nut and bolt are called for, as in case of accident or the necessity for readjustment they can be unscrewed, the fixture removed, repaired in the laboratory, and again screwed in place.

Let me say just here that this plan of nut and bolt is applicable where no roots are present for fastening one or more plate teeth, or one of my all-porcelain crowns, on a plate, instead of by the method of Dr. Bing, in which, if the teeth are broken, they cannot again be readjusted.[1] *Such bolts with threads cut upon them can be inserted in*

[1] It will be observed that at this date (1873) the method of removable bridge-work on *living teeth*, as well as pulpless ones, had been anticipated by me.

any part of a perfect crown or a filled one by the use of amalgam or gold if one will use it in such cases.

Next in importance to a crown that will meet all cases is the bolt which is intended to attach it to the root or roots and the cement for securing it.

In such cases as are outlined in Figs. 614 and 615 see that the pin is secure, and so placed, where occasion demands, that the lower part of the root need not be filled with cement, but that space be left for gases to escape through the taphole, which should be made obliquely from near the margin of the gum down below the cement, guarding against the liability of decay again occurring at the cervical margin by bevelling well the mouth of the cavity in the root. This once done correctly, there will be no need of again disturbing it. (Before setting the pin in any case the root should be temporarily filled at the apex to ensure against abscess.) Cases will present, however, where gases will form and escape. Here perfect security can be obtained by the taphole, as before described. This left open, a useful root is retained and without any apparent unpleasant odor. Do not condemn an abscessed root. Such can be made equally successful *where the peridental membrane can be restored to health.* Preserve every old root that has any length and in which the pin can be well anchored high up, even if the walls are fractured for an eighth of an inch below the gum or even where the root is split. In such cases dovetailed holes can be made in each fractured part, and the amalgam will hold them together. Even without this, if the pin has a good quarter-inch anchorage at the very apex it will be hard to dislodge.

To make doubly sure, when a taphole has to be made, that it is open from the apex, pass a fine annealed nerve-broach down alongside of the pin, build up the amalgam around it, withdrawing it after the crown is on and before the amalgam has set, holding the crown firmly while doing it; or it can be introduced through the taphole, and then be passed up to the apex, withdrawing it when the crown is in place. The taphole should be made near the cervix, leaving enough gum as a valve to keep out secretions. This practice is perfectly justifiable rather than have to lose a serviceable root. To a conscientious operator it is warrantable. In a very important root I go so far *as to allow or even force an abscess to form*, and then treat it through the pulp-canal and fistula. I save 75 per cent. of such cases rather than abandon them without any attempt at treatment.

Do not cut away the root very much, as a trifling space around the pointed pin will permit enough cement for strength. Roughen the inner walls of the pulp-canal, and they may be left conical without danger of the pin being withdrawn. One very great satisfaction to the patient, as well as to the operator, is that the rubber dam need never be used. The base of the root can be so prepared with a sharp burr that but little injury is done to the gum, and if it bleeds creasote or chloride of zinc or pressure of the thumb and index finger against the buccal and palatal walls will stop it or any serious discharge while the root is being filled with cement. After that the crown can be at once adjusted.

The band or rim about the cervix is justifiable in roots long decayed and exposed, where the dentine has been saturated until there is no cohesive power to resist the strain incident to crowning, or where the root is so small that the opening made for the pin greatly weakens the walls at the cervix, or where there is fracture already, partially or wholly, the length of root. The banding of every root is of no advantage, and is unnecessary work. Where the largest-sized pin is carried well toward the apex of the root it will sustain almost as much as the natural crown.

Soldering the *band to the crown* is not the correct way of using it, for the movement of the crown in the least destroys its value as a ligature to support the root.

The band should be adjusted closely to the cervix, and *be retained by the pin which passes through its centre* (Figs. 644, 645). So soon as the amalgam sets it holds the cap and band to the root, and nothing can move it unless the pin should give way. It permits the crown to cover the band on the labial or buccal side. The band can be made as a cap or without it to suit special cases. Amalgam will hold the band in place without the cap, but is not so strong as where the pin is made to pass through the latter and hold it.

In bicuspids and molars where the roots are separated, amalgam alone, with pins substantially placed in each root, will bind them firmly together. The band gives but little support as ordinarily applied, unless closely adjusted and held firmly in position to the root.

The permanent injury done to the peridental membrane by even the narrowest band justifies almost its general condemnation. But few are well fitted, and, aside from all else, it is a constant cause of suspense from the secretions. My long and varied experience in this line of operations assures me that where the root can be left well above the gum on the palatal side, and is very sound and hard, there is no call for any kind of band or cap. If the crown will be subjected to great strain from deep overbite, then the use of a large pin deeply seated, on the plan in Figs. 644, 645, will be most prudent.

The dovetailed opening in the root at the cervix, as in Figs. 626, 627, gives greater support, and where the root is large is sufficient. The dovetail should be carried an eighth of an inch in depth from the surface. Have the largest pin possible in the smallest pulp-canal, conserving all tooth-substance, and one can well feel safe in 90 per cent. of cases without the band.

The superior laterals and all the inferior incisors, where structurally weak, should be capped, but be sure the cap is held by the pin.

Where more than one crown is to be placed on in a continuous circle or line, cut off all the natural crowns at one sitting, instead of finishing one at a time, as I once advised. As many as four incisors can be inserted at one sitting, though two are as much as one generally cares to adjust at one time. Where the crowns have been well fitted to a plaster model there will be little difficulty in getting a good arch in the mouth, though a model is not necessary except for the superior or inferior incisors. If the operator has a large stock of bicuspid and molar crowns on hand, the fitting can be done at once. For special cases of very short teeth it

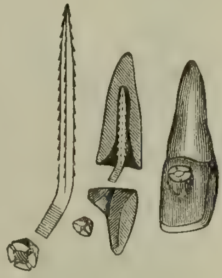
would be well to have a plaster model. The only objection ever urged against using amalgam in the roots to secure the pins is that the gums soon look purple or blue. This can occur only where the joint is not high enough above the margin of the gum and where poor amalgam is used. This is now entirely obviated by the use of my new crown with a lip on the labial or buccal side overlapping the root. Oxyphosphate of zinc can be used, but I prefer in the root always a special quick-setting amalgam, such as I am making. Gutta-percha will, in some cases, answer remarkably well, but it does not at all meet the requirements.

As to the objection against amalgam that it is too plastic and too long in hardening, let me say that in fact such is not the case unless the ordinary amalgam is used. I have never had to replace in a single case from such cause where the amalgam I have adopted is used in the crown. For the roots any first-class amalgam will do that does not take too long to set. When the pin is pressed up in the root with forceps, with the pin resting against the palatal wall of the tooth in incisors, there is no displacement. The pressure made on the crown "squeezes" out all surplus mercury and impacts the amalgam well around the pin, and with a lump of it well pressed with small points around the pin in the crown from the outside orifice it holds securely.

When amalgam is used the shade of the crown should be rather lighter than if a white cement were to be used, as the opacity of the amalgam adds a blue tinge to it, just as in plate teeth the shade is made darker by the stay-plate after soldering. Now that oxyphosphate can be relied upon, the crown can be secured to the root by it. When placed in the root in case of a fracture of pin it would be much harder to remove. But great strength and support can alone come from amalgam in the root.

Fig. 609 shows views of a superior central incisor crown as made from a plate tooth—pins crosswise—backed up with heavy gold plate entirely to the cutting edge and down to the base, where it rests on the root. The shape is given to the palatal surface by an extra plate struck up concave with a round tool on lead and nicely fitted up to the backing on the buccal side, extending as high up as the angle or about up to the cross-pins, and filled in with scraps of gold plate and then soldered. The drilling of the hole through the base and the countersinking on the palatal side are done with the engine. The base of the plate tooth should be cut off from the pins down to the cervix to leave more room for the nut. The nut ordinarily goes much closer to the backing than is shown in the sectional view of Fig. 609. The pin is barbed on its three sides, and thread-cut on the end passing through the crown. This is done with the ordinary screw-plate before inserting. For central incisors the pin of platinum wire should be No. 16, and for small lateral No. 18. The nut is made of half-round or oval gold wire about three thirty-seconds of an inch in thickness. The hole should be drilled before cutting it off from the main piece, and a female thread cut in it

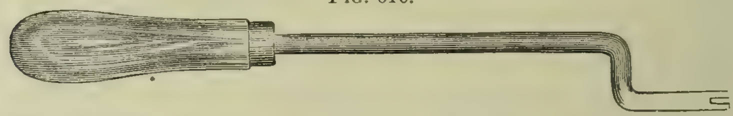
Fig. 609.



by a tap made of an old excavator filed down and run through the hole in a screw-plate of the size of the wire to be used in the root. The slots in the head of the nut should be crucial to admit of the screw-driver (Fig. 610) being used at each quarter of a circle. The nut should be tried upon the threaded part of the pin before being finally inserted, to see that no mistake has been made in the size of either the nut or pin. Such mistakes will sometimes occur. The pin is bent slightly to allow it to pass through the hole in the crown and stand in the countersink equidistant from all sides, so that when the nut is placed on it, it will bear on all sides of the countersink alike and the crown will not be tipped to one side. The pin, after the amalgam has hardened, can be bent with forceps to suit the countersink, taking care not to bruise the thread. The nut cannot be placed on at the same sitting, as the amalgam will not be hard enough to justify it.

Fig. 610 is a forked screw-driver bent at right angles, with a tube, not shown in cut, the diameter of the nut on the end of screw-driver, to slide up to the fork to hold the nut when being placed on the pin. This

Fig. 610.



form of screw-driver admits of getting into the palatal surface to put on the nut. It should straddle the pin, and be only wide enough to cover the diameter of the nut.

If so unfortunate as to injure the thread, repair it with a little screw-plate, as shown in Fig. 611. This may be made from a piece of steel dividing-file, cut down to about the size shown in the cut, and bent at right angles after heating it to a cherry red, and afterward drilling a smaller-sized hole than the pin through the short angle and tapping it with the same tap used in making the gold nut, then tempering it to a dark straw-color. This screw-plate can be run up on the pin in the root and recut its full length to the base. This obviates the removal of the pin after the amalgam has set. Taps and plates of various sizes should be kept on hand in duplicates.

Fig. 611.

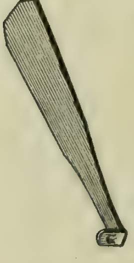


Fig. 612 shows a case of irregularity which was beyond correction on account of the poor character of teeth, their very ugly shape, their position in the palatal arch, and the age of the patient. In such cases I do not hesitate to cut off the crown, destroy the pulp, and place one of the plate-tooth crowns with a nut. To do so the crown must be connected to the root by a strip of heavy gold plate extending for a quarter of an inch or more to bring the artificial crown into the circle. For such cases the all-porcelain crown will do by soldering a pin on the plate at the proper point.

The nut and bolt are best where a crown has to be very long and there is a close and deep underbite, with little room for the crown without being too full in front. The gold backing gives greater

security, and should cover the whole palatal surface of the tooth. There are other special cases in which this plan is to be preferred, but only for superior incisors or cuspidati. It is desirable in bridge work for removal for repairs.

As before suggested, I should use it in attaching one or more teeth on a small plate where the roots have nearly all been lost, securing the bolt *with amalgam always* to either decayed or sound crowns or roots.

In this plan (Fig. 609) the pin should be of platinum or iridium, and placed in the root the same as for all-porcelain crowns, and adjusted before it is set to suit the hole in the base of the crown. The crown is now pressed hard into place by an adjuster (Fig. 647), gutta-percha is packed around the threaded part of the pin in the countersink for the nut until the next visit of the patient, when it is removed and the gold nut substituted. All excess of amalgam around the margin of the pins should be removed. The crown finally should be warmed, and a piece of gutta-percha stuck on to the base and pressed up, making a water-tight joint when the nut is screwed up. The gold backing should always be varnished to keep mercury from taking hold of it. Amalgam, well pressed up around the pin with bibulous paper, makes a good nut.

Fig. 612.

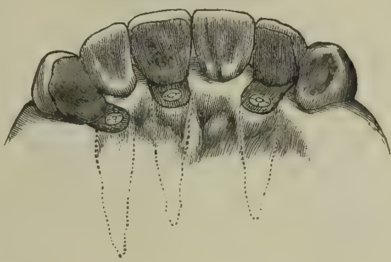


Fig. 613 shows an all-porcelain crown, sectional view, where the pulp is still living. A hole is made on the buccal and lingual sides of the root as far away from the pulp-canal as possible, and of size very little larger than the three-cornered pin, with an enlargement near the opening made with a barrel-shaped burr. The side of the undercut next to the crown should be as square as possible. In such a case the amalgam should be used quite dry, as the pins do not have to be pushed far, and can be well stamped in with narrow steel blunt points, always using the Japanese bibulous paper under the point of the instrument and on the amalgam, so as to make sure that the amalgam is solid. The crown can be placed in position at once, or the operator can wait until the next day to see that the pins are all secure; which is preferable.

Fig. 613. Fig. 614. Fig. 615.

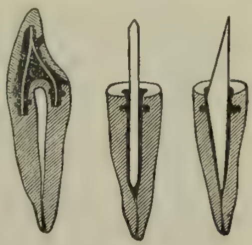


Fig. 614 is a sectional view of a case that requires tapping. The pin shows its thin flattened edge, with space on either side for gas to escape from the foramen. It is pressed up about three-fourths of the length of the canal.

Fig. 615 illustrates the same case as Fig. 614, giving a view of the flat side of the pin, and showing its bearing on either side of the canal by which it is prevented from lateral movement, the same as if the

amalgam encased it all the way. The gas escapes at the opening at T. (This opening should extend obliquely up to near the free margin of gum, and not as shown in the cut.) The amalgam extends no farther into the root than the undercuts near the cervix. This plan holds good in any tooth of one or more roots. Fit the pin closely to the root at the apex.

FIG. 616. FIG. 617. FIG. 618. FIG. 619. FIG. 620. FIG. 621. FIG. 622.

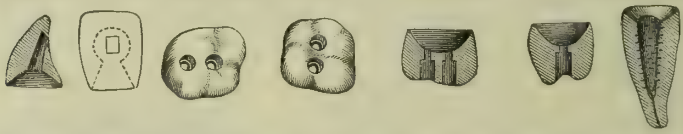


FIG. 616. Sectional view of an incisor crown as now made, from mesial side, showing the undercut at the point opening on palatal surface, the conical base, and the opening from the same to the retaining-grooves, with the exact relations.
FIG. 617. Palatal view of same tooth: *a* is the external opening for egress of alloy and for packing around the pin; the dotted lines around *a* show the recess or undercuts on the mesial and distal sides and near the point for retaining the crown, and its relation with the conical base.
FIG. 618. Grinding-surface view of a superior molar with the countersunk pinholes on the *buccal* and *palatal* sides.
FIG. 619. Same view of an inferior molar with the pinholes on the *mesial* and *distal* sides.
FIGS. 620 and 621. Sectional views of a molar and bicuspid crown, showing the countersinks and their relations with the conical base.
FIG. 622. Sectional views of an incisor root, showing the retaining-cuts made by the wheel-burr shown in Fig. 642.

FIG. 627.

FIG. 623. FIG. 624. FIG. 625. FIG. 628. FIG. 629. FIG. 630. FIG. 631. FIG. 632.

FIG. 626.

FIG. 623. Vaneer crown, with a loop of thin platinum ribbon baked in, and for extremely light work. With this but little of the palatal portion of the natural crown need be cut away, and it is particularly useful for inferior incisors. It is backed up with amalgam. Not intended for general use.
FIG. 624. The lip crown, which permits of a lap joint on the labial side, and conceals the color of the amalgam. It permits much of the palatal side of the crown to remain. It would be a most valuable acquisition if it could be had in greater variety.
FIG. 625. Base view, giving the triangular opening—first form of crown.
FIG. 626. Section of root, showing the improved manner of making a double dovetail in connection with the opening for the pin. It also shows the flat face of the root instead of the concave, as in Fig. 622, giving greater strength. The dovetail opening binds the root together, and is far less liable to split. Where not enough material remains, cut with small wheel-burr below the face, so inclined as to make the groove longitudinal with the axis of the root. This gives the amalgam a hold on the labial and palatal sides. There should be grooves cut in root, as in Fig. 622.
FIG. 627. Full base view, showing the dovetail grooves.
FIGS. 628 and 629. Concave crowns with a pin or loop of platinum burned therein, which is an outgrowth of the crown for roots, and intended for plate-work of all kinds as well as crowning. By using quick-setting oxyphosphate these short molars are easily crowned, without a central pin or roots. These crowns for original rubber and celluloid or continuous-gum work and for repairs are of immense value. But Fig. 616, the all-porcelain crown without pin, is the thing for all plate-work with rubber or celluloid in connection with a special pin of my metal or steel to connect it with the plate. Should it get fractured, it can as easily be replaced as pivoting a root. All this is done without reheating the plate in any instance. The crown with lip, Fig. 624, is preferable for this class of work. The pin should be placed in the crown with rubber and vulcanized. In case of fracture of crown the pin is utilized for another hollow crown, as Figs. 624, 630, 631.
FIGS. 630 and 631. My latest crown, without the concave base or large opening on palatal surface. Retaining cuts are made in the walls of the parallel oblong opening, same as in the root (Fig. 622), to secure the pin with gutta-percha or oxyphosphate. The base is slightly concave toward the centre in the bicuspids and molars, and none in the incisors. With this new oblong opening of parallel walls there is great gain. There are no openings on the exterior for egress of cement, the grinding surfaces being perfect. This gives an equally good tooth, and is easier to set by most operators.
FIG. 632. Base view of oblong opening for pin in the new crown, instead of the triangle. This is held by the slight groove made on the labial face for deposit of amalgam or cement, and acts as dovetail, same as triangular opening, but much stronger and easier made.

FIG. 633. FIG. 634. FIG. 635. FIG. 636.




FIG. 633. Showing a Bonwill crown with a large pin *cemented therein*, to be used by those who prefer it. Amalgam or oxyphosphate or gutta-percha will perfectly secure it, and can be pressed into the root by one operation. Then, in case of fracture, the regular Bonwill crown can be placed on without removing the pin. A platinum pin I have had baked into the tooth, but the simpler crown answers every purpose. In case of fracture there will be a much longer and larger pin for holding the crown than if it *had been baked in*. This is the original crown with hollowed base and pin baked therein, long before the so-called Logan crown.

FIG. 634. Sectional view of same improved tooth, showing undercut with wheel-burr before burning.

FIG. 635. Base view of a lower molar crown, showing the opening for pins for mesial and distal roots.

FIG. 636. Same view of an upper molar for the three roots, all parallel walls in the opening undercut.

FIG. 639. FIG. 640. FIG. 641. FIG. 642. FIG. 643.

FIG. 637.


FIG. 638.





FIG. 637. End view of a canal prepared for the improved combination metal-pin.

FIG. 638. End view of same canal, as in Fig. 637, prepared for a triangular pin, showing how much more of the mesial and distal surfaces have been cut away from it than in Fig. 637 for the improved pin.

FIG. 639. Sectional view[1] of an incisor crown and root, with the improved pin in its relative position to each, with the depressions made by wheel-burr.

FIG. 640. Sectional view of a superior molar, with the large angular pin in palatal root and two square pins in the buccal roots, one being shorter and not passing through the crown.

FIG. 641. Block of a molar and bicuspid, showing the countersunk holes for pins in the molar, and the hole in the mesial side of the second bicuspid where a pin is alloyed in and set into a decayed cavity in the distal surface of the first bicuspid, being held upon the molar roots and attached to the bicuspid by the alloy.

FIG. 642. Side and end view of the largest size angular combination-metal pin with the stamped serrations. The square pins are without serrations and double pointed, made of same metal and of equal thickness throughout. *All the pins as now made are without serrations and of double thickness.*

FIG. 643. The smallest-sized wheel-burr for grooving the canals for anchoring the pin and alloy. No need of more than *one wheel* on each shaft.

I have examined carefully the various methods of pivoting suggested by others, and believe that the plan which I here describe comes nearer to meeting all the needs than any other of which I have knowledge.

These all-porcelain crowns have three distinctive features: a concave or countersunk base; a triangular opening from the base to a point at or near the cutting edge of the incisors, the base presenting to the labial surface (at its upper portion this groove is enlarged); a peripheral margin or border resting perfectly flat on the root, the concavity of the base on the palatal side being at a much more acute angle than on the proximal sides. An anchorage is made in the incisors by a depression or undercut between the labial and palatal surfaces, opening on the latter.

[1] The sectional views of the incisor and molar, giving the relative position of the pins in the crowns and roots, should show pins of larger size. The pins as furnished should be filed down but little. It is not absolutely necessary that so many serrations should be made in the canals by the wheel-burr for retaining the amalgam and pin as are shown in the sectional view of the root of an incisor. While there are no serrations shown in the roots of the sectional views, it is understood that all the canals must have the serrations. The square pins in the canal need no serrations where amalgam is used in the root and crown; only where oxyphosphate or other cement or gum is used. The face of all roots should be concave or as shown in Fig. 626, and not as in Figs. 639, 640. Now, I save all tooth-substance possible.

In the bicuspids and molars the retaining-pits are nearer the grinding surface.

It is not necessary that the face of the root should be flat; it may be either concave or convex. We shall soon have the incisor crowns made with the labial edge convex, to run up under the gum and conceal the joint (Figs. 624, 631). The concave base of the crown prevents the amalgam from escaping under the heavy pressure exerted to force it into position and in impacting the amalgam and expressing the mercury. It allows of a dense body of material around the metallic pin, giving the equivalent of a pin the whole diameter of the base of the crown. It leaves no joint, the crown and root being continuous. The amalgam is so thoroughly hardened at once by impaction in the double concave of crown and root as to make a very firm operation. It prevents any possibility of the crown twisting upon the pin and root. In the event of fracture of the crown the convex surface of amalgam on the root makes the substitution of a new crown an easy operation. It enables the operator to fit the crown in much less time; it allows a proper position to be given to the pin with less danger of fracture therefrom; it permits of a larger quantity of amalgam in the crown, and is capable of bearing greater strain; it makes the permanent success of the operation probable, from the fact that it is absolutely jointless, and secures immediate solidity, even while the amalgam is semi-plastic. These crowns are capable of resisting the force of biting or mastication, because they are supported nearly to the cutting edge or grinding surface, the triangular opening from the concave base nearly to the cutting edge allowing the pin to be imbedded *in the labial face of the crown,* where there is the greatest amount of porcelain.

A round hole, with the concave base, would have its weakest point and relative strength through its greatest diameter, making the palatal side responsible for its retention. For incisors this one improvement cannot be overestimated. A porcelain crown otherwise would be too uncertain. With this nearly the whole of the palatal surface can be cut away. Without such an opening the pin would not go far enough past the base into the point of the crown to make it secure. To rely upon the base for retaining any porcelain crown would be impractical, the crown being much more likely to be immediately displaced before the amalgam hardened. The more acute angle of the base with the labial face is a marked improvement (Figs. 624, 631). The palatal portion of the root should be made to fit this. There is seldom a necessity to give any further shape to this base as it now exists. It should have its fine outlines preserved. No. 616 can be ground to fit any concave-faced root.

The pins, as now made, have marked advantages over the barbed triangular platinum pins. They are composed of a combination of metals which, while offering the greatest strength, allows the mercury in the filling to amalgamate the surface without injury to their substance; the pin is retained in the root without any serrations on its surface, which allows its easier insertion through the amalgam in the root. Serrations increase the size of the pin—are an obstruction to its passage through the amalgam, weaken it, making it more liable to break; platinum

will not amalgamate with the mercury. For these reasons I have long since abandoned their use. The size and shape of the pins I now recommend save time, have the greatest strength where the strength is most needed, and do not involve the cutting away of so much of the mesial and distal sides of the root, nor present any obstacle to the successful packing of the alloy around them. When the small roots of bicuspids and molars are to receive pins, square ones of a combination metal without serrations can be pressed up as far as desired. They are rolled stiff and then stamped, thus securing the greatest strength. They admit of being placed at any angle, and if broken are much easier drilled out than a triangular serrated platinum pin.

The amalgam to be used as the medium of union must set quickly and be very hard. Thus far I have found nothing better than the alloy I have specially prepared for this line of work, and, though it is costly, the superior results obtained by its use amply repay; I use No. 1. If mixed thick, it will set so quickly that the operator must work rapidly to prevent its being wasted.

The simple device which I have called an adjuster (Figs. 647 and 648) is a very useful adjunct in the operation. It requires considerable force to set one of these crowns according to directions—a force which cannot be applied with a mallet without danger of loosening or displacing the crown. Steady pressure with slight rotation will carry the crown into place if the amalgam is not too hard or if there is not too much of it. I would advise operators not to attempt to set a crown without one of these adjusters or its equivalent. Gutta-percha warmed and placed in the fork of the adjuster (Fig. 648), and the crown pressed into it, will make an exact special matrix for it, and every size and shape can be thus treated. Two adjusters for incisor crowns are enough. For the bicuspids and molars *soft rubber corks* are ferruled into the ends of adjuster (Fig. 647). There are two sizes, meeting every case.

A crown can be mounted upon almost any root if the alveolar process has not been too much absorbed. In all cases the canal should be cleansed and the foramen stopped with cotton or tin-foil. If an abscess is threatened, drill an opening through the gum at the apex of the root. Of course in an acute case it is safer to wait until the health of the root is established.

It is an advantage in every way to take an impression of the root, either with plaster or modelling composition, to get the size and shape of the crown. The articulation by a bite in wax is equally important.

Where much of the crown remains the easiest way of cutting it off is to place a half-inch disk in the engine and cut through the enamel on the labial and palatal sides; then with a spear-shaped drill make several holes as close as possible in the groove, and with a small fissure-burr run through them into one. It will easily break at this line. If the patient exposes the gum much in speaking or smiling, the root may be cut down with the burr or corundum wheel beyond the free edge to conceal the joint. With bicuspids and molars it is not necessary to go under the gum; a joint well made will not be observed, and the strength of the root will be preserved. If the root is decayed below the gum, after removing the softened parts replace with alloy; if it be split or have

very thin walls, a platinum band can be made separate from the crown. This will seldom be necessary, as the pin, anchored high up in the root, will be its equivalent.

In preparing the canal use first a small-sized, spear-shaped drill, carefully following the natural channel. Then follow with a larger one, taking care not to cut through the root near the apex. *On the mesial and distal sides cut away but little, as there is where fractures are most liable to occur.* The canal can be very tapering and yet hold the pin if the undercuts or grooves are well made all along the walls from the apex out. There need be but very little space around the pin. The *face of the root should not be countersunk* the same as the base of the crown, as all the dentine at that point should be retained to avoid fracture. The smallest-sized wheel-burr may be used to make an interrupted female thread at various points along the canal to hold the amalgam. By all means save all the walls of the root possible. The face of the root may be flat or concave, according to indications. The part of the pin that goes into the crown must be sharpened and pass above the hole on the palatal side of crown to ensure the latter from displacement from the tongue. In most cases it had better be flat on molars, curved on all others from mesial to distal.

The crown to be inserted should be inspected closely, as the retaining undercut in the incisors and the depressions in the bicuspids and molars may not be well defined. If not, the crowns are liable to work loose. If the base has been ground off in fitting, the edges should be bevelled again to a fine margin with a corundum point. The crown should be fitted to the root in the mouth, not to the plaster cast. The articulation should be clear, to avoid displacement. The pin should be as large as the previously prepared canal will admit. The pin must in every case be fitted, and in fitting it file only on the plain sides. Leave the end sharp, to offer the least resistance in passing through the amalgam. The end of the pin to be passed into the crown needs very little alteration further than to pass up above the palatal opening (Fig. 624). The middle of the pin should not be interfered with if it can be avoided. It is well to cut the pin a little short for incisors, as it may not get pushed entirely up in the root through the amalgam. The small square pins are used in the bifurcated roots of bicuspids and in the buccal roots of molars. They can be sharpened at both ends, and rounded or flattened to suit the case. The palatal roots of molars will generally take one of the largest thick pins, with one square pin in the largest and most accessible buccal root; in both, if the canals can be reached to prepare them. Each should have a pin, though one has to be so short as not to pass through the hole in the crown. If it enters the countersunk base it will support the root. The lower molars will require two of the largest-sized pins. As the support of the root is dependent upon the size of the pin and the depth to which it is inserted, the single-rooted teeth should have the very largest thick pin. If the root is thin on the mesial and distal sides, the thin, angular pin is to be preferred. When the pin is thoroughly set it is hard to fracture the root. The crown should go on easily and correctly over the pin, special note being taken of the position of the latter in the canal, so that it may be returned

at the same angle. Ordinarily these large pins do not have to be bent. If necessary, it had better be done with a hammer and before the mercury touches them. The pin should have free movement in both root and crown. Should it be discovered that the pin is too long after it has been packed in the root, it can be cut off with sharp forceps, pressing them up against the pin to prevent displacement. It can be sharpened subsequently with the corundum wheel without removing it.

To ensure an amalgamation of the pin with the filling, brighten the surface of the former before inserting. In the buccal roots of molars the pins need not be inserted more than a quarter of an inch, or even less in some cases.

The roots, crown, and pins being in readiness and arranged on the table, so that no mistake may occur from getting the pin in the wrong position, and the appliances necessary for the operation being at hand, the alloy preferred should be mixed a little thinner than if intended for a filling, especially where the root has a long canal. The shorter the canal the thicker the amalgam may be mixed. Mix only enough at one time for one root. Put enough amalgam in the canal to nearly fill it, *but do not pack it;* force a steel pin (Fig. 650), made for the purpose, of about the same size as the pin, to make way for the easier insertion of the latter. Then grasp the pin with suitable forceps and carefully but steadily press it up to its destination. If you cannot succeed in doing so, remove it and again use the steel pin. When in place use an instrument with a point small enough to pass between the pin and the root, and pack by tamping the amalgam around it (Fig. 649). A piece of bibulous paper placed over the point of the instrument will assist materially in carrying the amalgam before it. Before the amalgam has become too hard replace the crown to determine if the pin is in proper position; if not, it can be crowded to one side or the other with the tamping-tool. Should the pin be found to be rather long, it can be ground off with the corundum wheel, holding it meanwhile with the forceps. No attempt should be made to bend the pin after it has been amalgamated. If any amalgam has been left, and it is still plastic, it may be packed around the pin at the base of the root, using the bibulous paper as before directed. If not, mix again to complete the operation. Bank up the amalgam on the root high enough to fill the base of the crown. Try on the crown again to be sure there is not too much alloy on the root. The crown should now be forced home with an adjuster adapted to the case, removing the surplus amalgam if too much or adding if not enough. Remove and dry the crown, and fill up simply the undercut cavity near the cutting edge if an incisor, or the depressions in the crowns of bicuspids or molars, allowing none to extend into the cervical base. Finally, force it home with the adjuster (Fig. 647 or 648). Free mercury will be squeezed out on the palatal surface, which should be wiped off. Hold the crown in place with the fingers, with the bibulous paper under the tamping instrument, and consolidate the amalgam around the point of the pin in the crown on the palatal side, wiping off any free mercury which appears there. The excess of alloy at the joint must now be removed, care being taken to press the crown up with the fingers while this is being done. The amalgam packed

around the pin in the crown on the palatal side should be as stiff as may be to work readily. It is well to leave over some of the first mixing for holding the pin, and this will be about right for consolidating about this point, again using the bibulous paper.

If in a bicuspid or molar crown the pin should come so far through as to interfere with articulation, it may be ground off with the corundum wheel while the crown is firmly held.

The case can now be dismissed, with directions for the patient to use all care for several hours, and to return the next day, in order to make sure that the articulation is correct and to dress off the joint between the crown and root, which may be done with a small round-headed burr.

There are some cases in which the root cannot be filled with anything; if in a molar, the pulp-chamber can be relied upon to hold a headed pin or pins. When a taphole is required in the root, it can be made low down and at an acute angle, and the amalgam packed around the root-canal above the tap.

Should an artificial crown be broken, another can easily be substituted by burring off any excess of amalgam and using fresh amalgam, mixed thin to allow of ready adjustment.

Lower incisor roots, which have hitherto been abandoned to the forceps, can be crowned by this process.

Two crowns can be inserted on the root of one large molar with the assistance of the decayed proximal surface of an adjacent cuspid or bicuspid. (See Fig. 641.)

These crowns can be used for rubber or celluloid. In special cases, where plate teeth have to be backed with gold and attached to rubber, they are beautifully adapted, and if one is broken another is easily substituted on the old pin. A heavy metal pin is packed into the rubber and passed partially or entirely through the crown, to which the crown may be vulcanized at once or afterward cemented on.

For repairing celluloid or rubber or continuous-gum work these crowns serve a useful purpose.

The numerous letters of inquiry received by me since the publication of my article on this subject in the *Dental Cosmos* for August, 1880, lead me to the recognition of two facts: first, that the said article was not as explicit as it should have been, having, to meet the next issue of the journal, been too hastily written, and that my meaning has been misapprehended by many; and secondly, that the methods then described were not as perfect, and therefore not as satisfactory as now. Although I had been working at porcelain crowns since 1871, first using the nut and screw, yet I had had no opportunity offered me by a manufacturer to place them before the profession. The demand which was created for the crowns by that article led to their production before the manufacturers had recognized all the necessities of the case, and they were not made correctly.

Besides some radical changes in the methods of attachment, there are various collateral advantages now to be availed of which were not then obtainable. The correct principle by which to shape the crowns is better understood by the manufacturers; a specially-adapted quick-

setting amalgam has been prepared; a proper pin to meet all the requirements and a device for forcing the crowns into position are now furnished. The want of these things led to failure in many cases, but with such advantages as I have named there need be none hereafter.

Many of the failures which have been reported to me were, however, the result of a disregard of instructions. Some attempted to set the pin into the root before the amalgam was inserted, expecting to be able to thoroughly pack it to the apex of the root in this way. Of course they failed. Others have used gutta-percha instead of amalgam. A good oxyphosphate cement comes next to amalgam, but is less valuable than the latter, whether for strength, cleanliness, or protection to the root.

Of all the modifications recommended by others for setting the pin, that of cutting threads on the wire and in the root is the least desirable. There are various objections to this plan. It requires that the wire should be round, and of sufficient diameter to ensure strength at the junction of the crown and the root; the canal has to be unnecessarily enlarged, and the strength of the root is thus lessened. It is by no means an easy matter to cut a female thread in moist dentine at the apex of a root, and drill and tap must be perfectly adapted to each other or failure will result at best. A pin of sufficient diameter to give strength at the junction of the crown and root will be too large for the apex of the root, and if, to avoid this difficulty, a smaller wire is used, it will not have the strength required, and the thread will be likely to break when screwed home. Moreover, by this plan so much of the distal and mesial surfaces of the root has to be cut away to facilitate the packing of the amalgam that the root is unnecessarily weakened. The triangular pin formerly recommended, though better than the round wire, is open to the same objections. Other disadvantages of this method are that it meets a very limited number of cases, as where decay has already enlarged the canal (even here the apex of the root is likely to be unsound); and if, on account of the breaking of a crown, it is found necessary to remove the wire, it is almost impossible to get it out from the apex, and when done the thread in the canal is destroyed. To ensure absolute success by this plan the wire must be of an exact size or the thread will be valueless.

A pin has been recommended of a conical form, with screw-thread, to be forced through the soft amalgam previously placed in the canal. The amalgam, however, would not be likely to remain in place while a screw was being turned round in it, but would be drawn away from the apex. Moreover, in most cases the pin has to be bent to suit special needs, which bending should be done before the pin is fastened in the root. A screw would not work satisfactorily after bending, and could not, of course, be bent after its permanent insertion in the canal.

It would be well if every one should set a crown on the root out of the mouth before attempting the operation in the mouth. A sectional thread can be made in the walls of the root to the very apex with a wheel-burr, and if after the amalgam has become hard the root be

split, it will be found that the amalgam has been forced into every portion of it.

To solder a pin to a plate tooth and pack gold or any plastic material around it in the root, or to fill the root with a plastic and force the pin up through it, is not a good method; and if the face of the crown should be broken—an accident liable to occur—it is no easy matter to remove the pin. It is unmechanical.

FIG. 644.

FIG. 645.

FIG. 646.

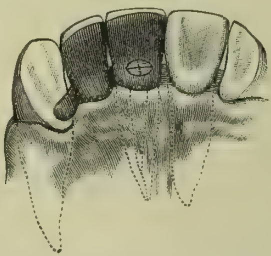


FIG. 644. Platinum or gold cap and band for covering face of root, with an opening for pin, which should fit closely to the opening. The pin, when the amalgam is packed around and over it, securely holds it to the root independently of the crown, and gives it the firm support that no band on the crown alone can give. It becomes a part of the root, held there by the amalgamated pin forming a cap or head around the pin on the outside of cap.

FIG. 645. Showing the relation the pin holds to the cap and band. Pin put in first, and packed securely around it, and band or cap afterward.

FIG. 646. A case where the root of a central incisor supports its own crown and that of a lateral soldered to it on same plate, and is secured to the central root by the nut-and-bolt process. An arm of gold rests against the palatal wall of the cuspid to prevent the movement of plate forward. A threaded pin can be fastened by amalgam into the cuspid, and a nut used, securely holding it thereto as permanently as on the central root (not shown in the cut). Cases of from two to six or eight teeth can be retained by this plan where two or more roots can be utilized.

To prevent the loosening of the nut any cement packed around it will be most effectual, and allow of readjustment where accident occasions a removal for repairs.

This one application is assurance for all bridge-work, since it has been in use since 1873. To permanently secure it by a cap or pin has no true merit. It should be easily removable, and by any dentist in any part of the world.

The all-porcelain crowns can be used instead of plate teeth by soldering a pin at the proper place in the arch to retain it, and held thereto by any cement or gutta-percha which is firm enough, as described in Fig. 612. This gives to every dentist a tooth to be kept in stock that will meet quite every case in crowning, bridge-, or plate-work.

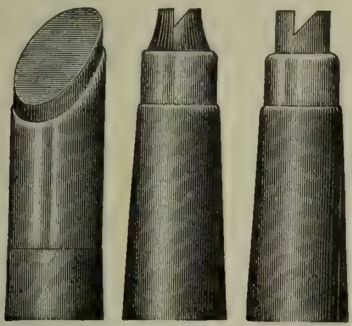
As success in setting a porcelain crown depends largely upon the thorough consolidation of the alloy around the pin and between the crown and root, I have devised an appliance for this purpose which I consider indispensable. I claim that neither the fingers, the forceps, nor the mallet will so effectually prevent the liability of crowns being displaced immediately after the operation as will these adjusters. (See Figs. 647, 648.) The adjusters for bicuspids and molars have heavy ferrules and *soft rubber ends*, which are *self-adapting* to the various sizes and shapes of the grinding surfaces of the crowns, and to any angle, the two alone answering for all such cases. They are also specially adapted for removing any free mercury in amalgam fillings by pressure upon their surface.

The pins (Fig. 642) were designed by me, and are the result of large experience in setting porcelain crowns. They are especially adapted to this use in shape and size, and are made of special metal. Their employment saves valuable time to the operator, which would be consumed in the preparation of a pin for each case, and success in the setting of an artificial crown is also better assured. They are stamped from rolled

metal, so as to ensure the greatest strength with the smallest bulk, and require but little fitting for adjustment. Their shape allows of setting in four different positions or angles.

To secure the strongest operation, No. 1 pin should be used wherever a single root is to be crowned. No. 2 is used in buccal roots of superior molars, with a No. 1 for the palatal root.

Fig. 647. Fig. 648.



Crown Adjusters.

The pin, being the greatest factor, should always be as heavy or thick at the cervical border as can be used, and pass as far into both root and crown as possible. When more than one pin is used, they need not enter the roots more than a quarter of an inch.

Where a crown has to be replaced from fracture, cut off the surplus amalgam around the pin with the engine and cutting-pliers until the new crown fits nicely. Fresh amalgam having been laid over the old amalgam and the crown being pressed up as before, the repair is complete. The crowns are not made to allow of their being pressed up over the end of the root, as in the Richmond plan of a gold band, as there is no necessity for the band, save in the few instances named in a former part of this article.

The adaptation made by me as far back as 1880 of the original crown to all kinds of plate work, to obviate the necessity of reheating any plate for repairs except fracture or breakage, cannot be overestimated. When the hollow crown will not do, the hollow base with pin baked therein (Figs. 628 and 629) will complete what is lacking in Figs. 616 to 624 and 630 to 636, these being also particularly applicable to bridge-work. These forms, when well made, would quite fill every demand upon us for crowning a root or for plate work.

I have long since abandoned amalgam for attaching molar crowns to roots, filling the latter only with it, but use instead red or white gutta-percha, and in Nos. 630 to 635 a cement alone of any kind, gutta-percha forming the union between crown and root in nearly all cases. This plan is stronger and easier in every respect, using amalgam only in roots. The open countersunk crowns (Figs. 616 to 621) must be filled in with amalgam or cement on the grinding or palatal surfaces.

Where used for plate work a special pin is used that unites tooth and plate by metal, and renders repair easy, because of more material to attach to, and the pin left high up in crown, on which another perfect one can go secured by any cement, the same as in pivoting.

Wherever amalgam is used, either in crowning or filling natural teeth, the Japanese bibulous paper or fine muslin or linen should be used. It is a sine quâ non.

If we could have a tooth for the work as strong as the English crowns, we could ask but for little more. This *I can promise in the future.*

There is one great advantage my own pins have over any other metal: they can be more easily removed from the root by boring with spear-

FIG. 649.

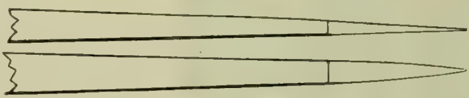


FIG. 650.

FIG. 649. A thin, square-edged tool for compressing amalgam around the pin, to consolidate the amalgam, using bibulous paper over the latter always.

FIG. 650. A thin-bladed knife of steel, pointed, same size as the pin, for forcing up through the amalgam to make way for the pin. Sometimes it becomes so impacted that a spear-pointed drill has first to be inserted to loosen the amalgam.

drill directly through them, thereby not enlarging the original opening in the root. Besides, by inserting them in roots, they are beyond comparison as an adjunct for supporting amalgam or gold fillings, as no female thread has to be cut in the dentine for a screw—a thing almost impossible, and at best uncertain.

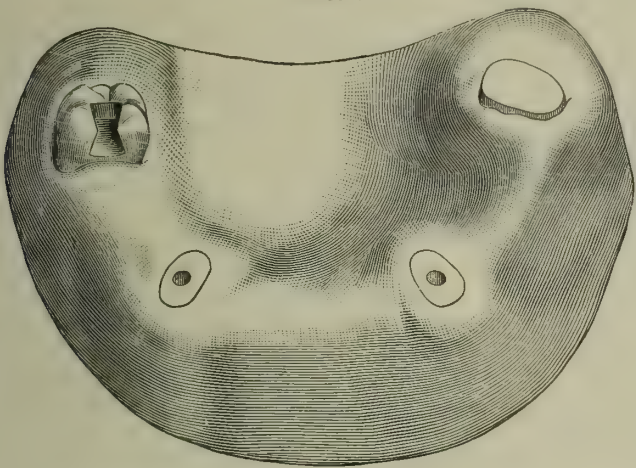
I give this plan to the profession with the assurance that there is no other operation in dentistry which will so delight patients. Instead of crowns patched up with gold, amalgam, gutta-percha, etc., we have in this plan "art concealing art," recommending itself to the common sense of the patron and enabling the operator to get well paid for his labor, and suiting itself to the purse of every class of society—a plan which will enable us to blot from our practice in a great measure the necessity for extensive bridge-work or dental plates.

CROWN- AND BRIDGE-WORK.

By WILBUR F. LITCH, M. D., D. D. S.

For the systematic study of constructive details in tooth crown and bridge-work the model of an upper palatine arch (seen in Fig. 651) may

Fig. 651.



be taken as representing a typical case. It contains two strongly-planted cuspid roots and the roots of the right twelfth-year molar, the corresponding tooth upon the left side being sound with the exception of a coronal cavity of inconsiderable size. To these four points of support is to be attached a denture consisting of twelve teeth, this probably being the extreme limit to which bridging processes can be satisfactorily carried. The molars here represent the abutments and the cuspids the piers of the dental bridge, and may for convenience be designated anchorage-teeth or roots, as distinguished from the intermediate or bridge-teeth.

The first point to be decided in the construction of such a case is the character of the attachment to these points of support—whether by caps, bars, or retaining-pins—as upon the character of the attachment will depend the nature of the preparation of the several anchorage-teeth.

In making so large a bridge-piece strength is a paramount consideration, and this quality can best be ensured by well-fitting caps or crowns for the cuspids and the right molar. For the left molar a well-anchored

bar will give adequate support and necessitate less destruction of tissue than would the proper adjustment of a cap or crown to the tooth.

The necessary antiseptic treatment of the pulp-canals of the cuspid and right molar roots may for present purposes be regarded as accomplished, and a description of the details of their preparation for the reception of caps be at once begun.

Preparation of the Anchorage-roots.

As the cuspid roots are to be supplied with porcelain crowns placed upon the metallic caps, it is desirable, in order to secure ample space for them between the roots and the occluding lower teeth, that the face of the roots should be cut down—at least to a level with the gum upon all sides, and to a little below the level in front.

In order that the ferrule of the cap may be closely adapted to the sides of the root at all points, its entire circumference, as far as the ferrule is to extend, should be made parallel with the long axis of the tooth. Fig. 652 gives a sectional view of a typical cuspid root from neck to apex; the perpendicular line A to B indicates the point to which the projecting edge of the neck should be cut away. Fig. 653 shows in transverse section a cap fitted over a root in which this line has not been followed, the effect being a projecting ledge at C, D irritant to the soft tissues and affording a nidus for the accumulation of secretions and the development of fermentative decompositions. Fig. 654 shows the conformation of the neck of a typical molar tooth in which the necessity for abscission of the flaring edge (to the line A B) is even greater than with the average tooth of the cuspid or incisor series.

Fig. 652.

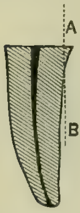


Fig. 653.

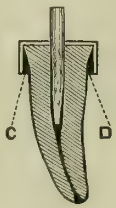


Fig. 654.

The removal of tooth-substance in this location and for this purpose can best be effected by means of Dr. Jacks's "hard-bist" chisel-excavators Nos. 13 and 14; Dr. Bennett's chisel-excavators Nos. 5 and 6 are also useful. All instruments must be used with well-directed and well-guarded force, to avoid injury to the soft tissues. Suitably shaped burrs and corundum-points are often of service and at all points above the gum-margin can be used with freedom; beneath the gum they are apt to wound the tissues and leave a roughened surface difficult to smooth.

Retaining-pins are not usually required in the pulp-canals of molar teeth; but when caps with porcelain crowns are to be mounted upon incisors and cuspids, they are of the utmost advantage, and are often quite indispensable. For the most effective service these pins should be of sufficient size, the average requirements being four-tenths of an inch as to length, and a diameter of about No. 13 standard gauge at the point of attachment to the cap. These measurements, however, can by no means be arbitrarily adhered to, as they must frequently be modified in conformity with the exigencies and requirements of individual cases, the chief determining conditions being the size and shape of

the root itself and the possibility of safely enlarging its pulp-canal to the requisite dimensions.

Enlarging the Pulp-canal.

This is a process demanding the utmost care and delicacy of manipulation. The canal usually occupies very nearly a central position in the root, and as long as its line of direction is followed in the drilling processes there is but little danger of perforation of the root-walls; but, unfortunately, there is usually but little external indication as to what this line of direction is. Frequently the root is abruptly curved, often it is very short, sometimes very much compressed laterally; so that a blind forcing of instruments through a supposed central channel is in the highest degree hazardous, and in a majority of cases is pretty sure to end in disaster. In carefully conducted manipulations the element of chance is eliminated and all the procedures are based upon exact knowledge. To this end an exploring-probe of sufficient fineness and elasticity must be employed as a guide; this, passed as far as may be practicable into the canal, will indicate with accuracy the position which the root occupies with reference to the plane of the palatine vault. Drilling should not go beyond the point up to which this can be determined, but up to that point the canal can with suitable care be safely enlarged. When this is done, the probe can often be still farther advanced, and so by degrees the desired increase in size be safely effected. Only when the operator is perfectly sure of his ground should the burring-engine be employed in this process; well-sharpened hand-drills are far safer: they cut with deliberation and, backed by a skilled hand, almost with intelligence. The experienced operator learns much from the character of the resistance offered to the progress of the instrument, and no little from the sensations of the patient, there being very generally a slight sensitiveness developed as the zone of vitalized matter near the periphery of the root is reached. This may be taken as a sure indication that—in that direction, at least—the drill has gone to the limits of safety. The general shape of the enlarged canal should correspond to its original form—a gentle taper from crown to apex.

Alloys for Metallic Caps.

As bridge-cases are designed to remain as fixtures in the mouth, it is for every reason desirable that only non-oxidizable metals, such as gold and platinum, should be employed. When gold is used, it must be of the highest possible grade consistent with strength. For making caps either coin gold (21.6 carat) or 22-carat gold is to be preferred. The use of solders containing zinc should be restricted to the narrowest possible limits, the union of pieces of the higher grades of gold being preferably accomplished by means of alloys of a less carat, but reduced with silver or copper only, singly or in combination. (See section on Metallurgy.) These can be used as solders with almost as much facility as though they contained zinc, the difference being that, carat for carat, their fusing-point is higher, and that the avidity of zinc for gold causes

solders of which it forms a part to flow to all near surfaces with swiftness and precision, to spread over them smoothly, and to cling to them with tenacity, whereas alloys of gold, silver, and copper only, finding around them no special affinities stronger than their own bonds of union, manifest a tendency to roll up into globular masses. This tendency, however, can readily be overcome by the judicious application of heat in conjunction with fluxes. The objection to the use of zinc alloys is that they are brittle and readily oxidized. Zinc seems to be specially obnoxious to platinum, thin sheets of that usually tough metal being rendered quite friable by a union with it. When it becomes necessary to use zinc solder in connection with platinum, it is well first to fuse upon its surface a protective film of pure gold.

The following is a good formula for a gold solder containing zinc; its use in connection with bridge-work will be subsequently indicated. It is 18.209 carats fine:

Gold coin (ten dollars)	258 grains.
Spelter- (or brazier's) solder . . .	24 "
Silver coin	24 "

The spelter-solder here called for is simply a more fusible brass made in the proportion of sixteen parts of copper to twelve parts of zinc. In making the above alloy, first melt the gold, then add the silver, and lastly the spelter-solder, using large quantities of borax, to prevent oxidation. This solder can be used in soldering 18-carat or any of the higher grades of gold.

Making the Metallic Caps.

In making the cuspid caps it is well first to prepare the retaining-pins, which should be constructed of platinum alloyed with iridium. The desirable length and size for these pins has already been indicated; in shape they should be at the larger end very nearly cylindrical, but gradually tapering, to correspond to the shape of the pulp-canal. Squaring the sides of a cylindrical pin or making it triangular in shape reduces its strength by removal of substance, while for its admission into the pulp-canal there is necessary just as great an enlargement of its calibre, and consequent weakening of the root, as before. The only advantages which can be claimed for the square or triangular pins are that their angles are readily barbed and that their shape prevents rotation of the crown; but in well-fitted artificial crowns the tendency to rotation does not exist, and the sides of a cylinder can be barbed sufficiently for all practical purposes.

To make the ferrule portion of the cuspid caps, take a strip of 22-carat gold[1] about one-fourth of an inch wide and of sufficient length—determined by a pattern cut in heavy tin-foil—and in thickness about No. 27 standard gauge, and with suitable pliers and other instruments bend it into shape, so that it will fit closely to the root at all points and pass up under the gum. This is the only very painful part of the pro-

[1] As 22-carat gold has a higher fusing-point than coin gold, it is to be preferred.

cess, but the suffering can be greatly mitigated by the use of local anæsthetics, such as cocaine or carbolic acid, either of which is effective.

No set rule can be given as to the width of the completed ferrule: a

FIG. 655.

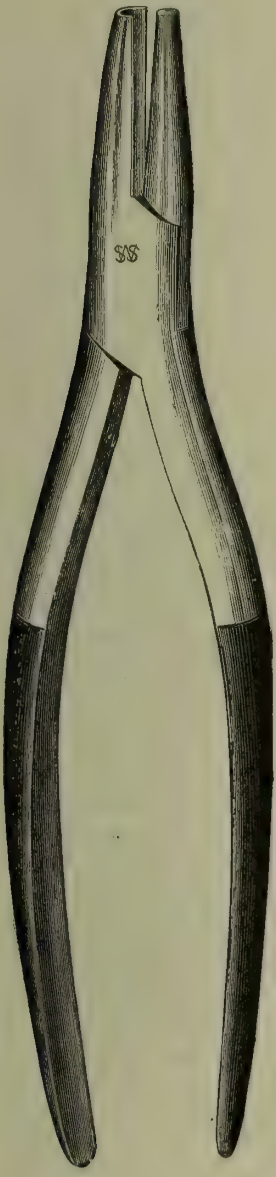


FIG. 656.

FIG. 657.

FIG. 658.

FIG. 659.

width greater than the eighth of an inch is rarely necessary; often the shape of the root and the condition of the tissues render a much narrower one desirable. A ferrule less than one-twentieth of an inch wide is hardly likely to be of much use, but one of that width, if well fitting and held to position by a retaining-pin, may do good service.

Theoretically, a metallic band placed beneath the gum should prove a source of irritation; practically, if properly adjusted, it does not. If roots are broken away to the alveolar edge, a ferrule cannot be used, but in the normal state the distance between that edge and the surface of the gum, while varying greatly in individual cases, is considerable in all; and if the operator has skill, the ferrule can generally be applied.

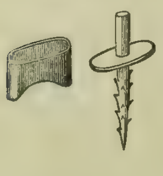
Various plans for securing accurate models of the root—upon which models the cap can be constructed—have been devised; some of these possess merit and in inaccessible and otherwise difficult cases are of decided advantage. As a general rule, however, the writer finds that the time occupied in making such models is almost as considerable, and the pain inflicted in securing the impression almost as great, as in shaping the ferrule to the root *in situ;* and when all is done, no model is an *exact* reproduction of the parts which it represents, and, as a hair's breadth of variation is often sufficient to cause a decided maladjustment, the final fitting must, as a rule, be done in the mouth.

In fitting the ferrule the two ends of the gold strip should terminate

in an overlap, which, for convenience of arrangement, is preferably to be placed upon the mesial side of the ferrule. In forming the overlap, the opposed surfaces should be smoothly and uniformly bevelled, their thickness in the process being reduced fully one-half; so that when soldered the overlap will not be thicker than the rest of the ring. In shaping the ferrule the pliers shown in Fig. 655 are invaluable. The thin burnishers seen in Figs. 656, 657, and 658 are also of great service, both in pushing the gum from around the root and in pressing the ferrule closely to its sides, this latter process being greatly assisted by a long and serrated foot-plugger such as is shown in Fig. 659. Slight changes in shape can often best be effected by aid of a small office anvil and a delicate hammer. When, by these and other agencies, the ferrule has been made to grasp the root tightly and fit it perfectly, the overlap may be soldered. First the exact point at which the overlap terminates when the ferrule is tightly pressed around the root must be indicated by a clearly-defined line traced upon the gold by a pointed instrument drawn along the terminal edge of the overlapping portion of the plate. When pressure is withdrawn from the ferrule, the elasticity of the gold will cause the two ends to spring apart. To overcome this tendency, remove the ferrule from the root and again press the two ends together up to the guide-line and a little beyond, so that a closer grasp upon the root may be had. Hold the overlapping portions with suitably shaped foil or soldering pliers, and over the flame of a spirit-lamp or a Bunsen burner bring the ferrule to a red heat. This annealing process effects a rearrangement of the molecules of the metal, so that the two ends of the ring remain in absolute contact, with no further tendency to separate so long as the gold is not again bent. Borax can then be applied and the joint soldered. For this purpose use simply 18-carat gold plate without zinc.

The remaining steps in the construction of the cap are very simple. A piece of gold of the same grade and thickness as that of which the ferrule is formed is so shaped as to fit accurately within its inner surface and cover the face of the root, thus forming a crown-plate. The ferrule is again placed on the root, to whose free surface the crown-plate is accurately adapted by pressure, bending, etc. At the point where the crown-plate covers the pulp-canal an opening is made of sufficient size to allow the passage of the retaining-pin. Through this the pin is pushed up into position in the root, which has been prepared for it by enlargement of the pulp-canal as already described. For convenience in manipulation, the free end of the pin is made longer than the canal, and for the time is allowed to project about a quarter of an inch beyond the tooth. The free end of the ferrule should be cut down nearly, but not quite, to a level with the crown-plate. The three pieces are then to be united by the same solder as that used to join the ferrule—namely, 18-carat gold plate without zinc. Fig. 660 shows the ferrule; Fig. 661, the crown-plate with an opening through which the retaining-pin passes.

Fig. 660. Fig. 661.



If the ferrule fits tightly, it will often be found impracticable to hold

the three pieces together even by a strong resinous cement when the attempt is made to withdraw them from position on the root for investment previous to soldering. In such cases the better plan is to dispense with cements, pass the three pieces firmly into their respective places upon the root, and run over their exposed surfaces a small mass of impression plaster, which, when hardened, will form a matrix in which the several parts can be replaced one by one as they are withdrawn from the root, and thus be restored to the same relative positions they occupied upon it.

The investment compound can then be placed around the pin and within and around the ferrule, thus holding them securely in apposition during the soldering process, the original matrix being cut away as soon as the investment has hardened. An investment for this use is best made of equal parts of plaster of Paris and marble-dust. Ordinary beach-sand is too coarse and asbestos too fibrous to pack nicely into small spaces. Pulverized pumice might be used, but it is far more apt than is marble-dust to form a slag with the borax used in the soldering process. Beach-sand, too, at high temperatures, has the same tendency.

The investment as mixed for use should have a firm consistency, and should be securely packed into the ferrule and around the pin; the outer surface, too, of the ferrule should be well protected by it. Before soldering, all plaster should be removed from around the retaining-pin and from the joint between the crown-plate and ferrule, as it is desirable that these points should be well filled by the solder, and the presence of plaster prevents its inflow.

When removed from the investment after soldering, the cap will present the appearance seen in Fig. 662. The sides are perpendicular, so that the root may be firmly grasped at all points, as seen in the cut, and are made somewhat concave laterally, to conform to the contour of the gum-festoons and alveolar septa when in the normal state. When, however, as often happens, the tooth is decayed proximately for a considerable distance below the gum-margin, it is necessary to give the corresponding lateral wall of the ferrule a convex rather than a concave shape, to the end that the root may be grasped by it beyond the floor of the cavity.

FIG. 662. FIG. 663.

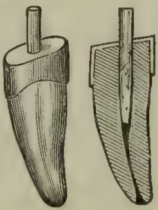


Fig. 663 shows a sectional view of the same tooth and cap, the retaining-pin passing into the pulp-canal through the opening into the crown-plate previously described. The close adaptation of the ferrule to the walls of the root is here very well shown. The width of the ferrule has, however, been exaggerated in the drawing; in a great majority of cases a narrower one would be both necessary and desirable.

The outer face of the ferrule should be bevelled to a thin edge chisel-like in form, so that when in position upon the root it may present the least possible projection beyond its periphery. If the edge is left square, a sharply-defined ledge will exist, which for every reason is to be avoided.

Making the Molar Cap.

Reduced to its simplest elements and allowing for certain obvious differences in the conditions, the making of the molar cap can be accomplished by very much the same processes as those described in connection with cuspid caps—that is to say, the ferrule should be made of the same metal and can be shaped in the same way; but in all its dimensions, except that of thickness, which may be the same, the ferrule must be larger, corresponding to the increased size of the root. In width the ferrule should extend from the root, below the gum-margin, to the line of occlusion with the antagonizing teeth, thus to a great extent reproducing in gold the size, and to some extent the shape, of the original teeth. After the overlap of the ferrule is closed all that remains to be done is to attach a crown-plate and form cusps, a retaining-pin being, usually, unnecessary.

In making and attaching the crown-plate the plan suggested by Dr. C. N. Richmond—one of the first to devise and use this form of crown, and whose name is often attached to it—may be adopted. The details of this plan are embraced in the following clear description of Dr. Richmond's method of constructing a crown as given by Prof. Stellwagen,[1] who obtained his instruction from him:

"The gold should be of the fineness of coin—for convenience and economy the five-dollar gold-piece is the best—and should be of the dark, rich color of the recent United States coinage, the alloy of which is mostly copper. The coin is passed through the rolling-mill until reduced to about No. 27 gauge, which makes it of an elliptic shape, about $3\frac{1}{2}$ inches long, and perhaps a trifle wider than the original coin. The ends and sides are now pared off, to bring the plate to a rectangular shape, and, after weighing, the parings are melted upon a piece of jeweller's charcoal and one-fifth of their weight of fine brass wire cut into pieces about half an inch in length is added. Care must be taken that the melted gold is well covered with flux (borax), to prevent the burning of the brass; which latter may be added piece by piece at a time, so as not to chill the button too rapidly, one end of each being pushed into the molten button.

"This forms the solder, which is rolled down to about the thickness of the plate and cut into small pieces as needed for use.

"The root is prepared by filing or grinding with the stump corundum wheels or files to flatten the exposed end. A strip of the plate is cut wide enough to reach from the alveolar process to a little above this end of the root and long enough to encircle the same; for this a pattern of soft lead or tin-foil may be tried and made as a guide. This strip of gold plate is now bent and filed so as to make a close-fitting ferrule; indeed, it may be made a trifle smaller—say two or three times the thickness of the plate—as it is liable to stretch, the ends abutting edge to edge and these soldered together. A piece of plate large enough to cover the upper or crown end of the ferrule is now cut, and a small piece of the solder flowed over one side of it, when it is laid with the soldered side down, upon the end of the ferrule, properly covered with

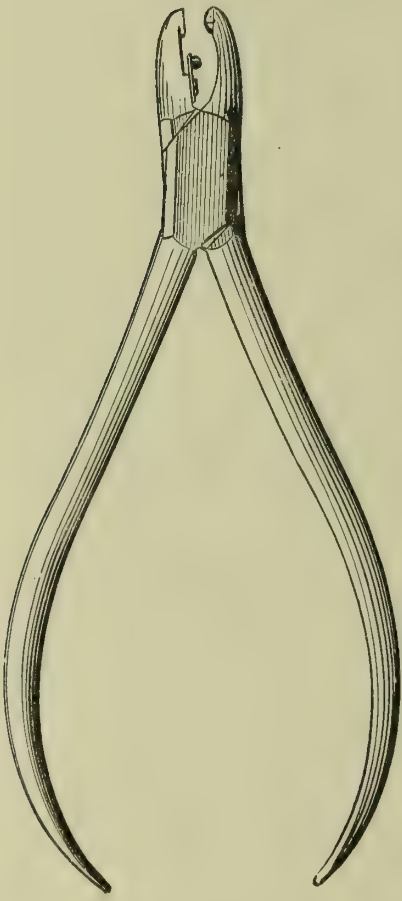
[1] See Coleman's *Dental Surgery and Pathology*, pp. 259, 260, 261.

borax ground in water to the consistence of cream; and by heating to the melting-point of the solder, the blowpipe-flame being thrown down upon it, this lid or end is united with the ferrule proper. With the file the edges of the lid are dressed down level with the ferrule, the outside is smoothed, and the end next the bone has the proximate surface cut away with a round file, to correspond with the festoons of the gums and septa of bone between the teeth, where they hang lower. The edge next the gum is then slightly bevelled from the outside, making a chisel or gouge-like edge, to pass up around the root and in the closest contact with it. The ferrule is now placed upon the root and pushed or driven home, and the points for putting on the cusps of the crown are marked. Buttons made by melting scraps of the coin are first slightly flattened by the blows of a hammer while they are lying upon a smooth steel surface, then tried as to size and shape, allowing a very slight thickness for grinding off, to perfect the occlusion or biting against the antagonizing teeth after the crown is finally placed. The part of the ferrule that is to be next the lip or cheek may have a slight mark scratched upon it, for the sake of convenience in replacing the crown, and the ferrule may then be drawn off from the root by working it down with a dull hoe-excavator, being careful not to nick the edge of the gold or scratch the tooth.

"The ferrule should now be solidly filled with moistened sand to which a little plaster has been added, as for investing plates and artificial teeth for soldering, and the whole, excepting the top or lid, should be embedded in a slightly conical mass of the same. The buttons to form the cusps should be placed in position on the lid of the ferrule as soon as the plaster has dried, the solder piled up around the buttons, and the whole covered with the borax flux. To attach the mass, it must now be heated by the blowpipe until the solder is melted and flows freely, forming a perfect crown in shape; but care must be exercised not to flake off the plaster investment and expose to the flame the soldered portion of the work already finished, lest the ferrule come out from this heating defective or with a hole burned through it. The crown is now shaped, smoothed, and afterward polished upon a felt wheel, it being held in contact with the latter by a stick fitted into the open end of the ferrule. Care must be taken that we may be able to recognize readily the buccal or labial side either by the cusps or by allowing the scratched mark to remain. In cases where the appearance of the gold is objectionable, a plain porcelain tooth of proper shade may be fitted, backed, and soldered on in place of the outside cusp or cusps; and in such teeth it is best that the ferrule should not come below the free margin of the gum upon the labial face."

In bridge-work cases the chief objection to this method of constructing a crown is that too much of the zinc-alloyed solder is used, there being always the danger that in some one of the several reheatings required in building a bridge-piece the crown may become unsoldered. The method, too, makes no provision for contouring, the walls of a crown thus constructed being necessarily almost perpendicular, and to that degree unnatural in appearance, and, as a consequence, inartistic in effect. This defect, however, can now to a great extent be remedied

FIG. 664.



by contouring-pliers, shown in Fig. 664, which are constructed for the purpose.

Since the introduction of the so-called "Richmond crown," innumerable devices for simplifying the making and mounting of metallic crowns or caps for teeth or roots of teeth have been brought forward; to describe them all in detail would be tedious and unprofitable. Many of them possess great value; others are based upon conclusions drawn from experience with a single case or from a limited number of cases. Many, while professedly labor- and time-saving, really, on the average, demand more of both than do methods more difficult, perhaps, but also more exact.

For a tooth so large in circumference at the neck and so relatively inaccessible as is the left molar in the model under study the writer always prefers to make the ferrule in two sections, causing each section to encircle a little more than one-half the root, the ends overlapping midway of each proximal surface. When skill is once acquired, this division of the ferrule will be found greatly to facilitate exact adaptation, and at the same time to spare the patient pain.

Very artistic results can be obtained by striking up the two halves

FIG. 665.

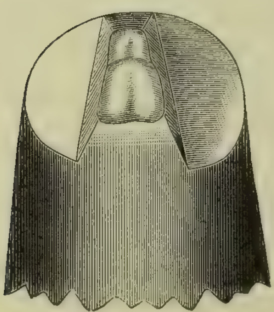


FIG. 666.

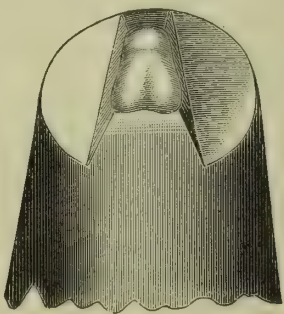
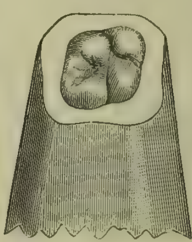


FIG. 667.



of the ferrule and a crown-plate upon dies made from natural teeth corresponding as nearly as may be in size and shape to the typical form of the tooth to be capped. Figs. 665, 666, and 667 represent a series of such dies made from the model molar tooth seen in Fig. 668. It will be observed that around the neck of the molar a groove has been cut down to a line perpendicular to the long axis of the tooth, as previously directed in the instructions for preparing roots for ferrules. In order that the edge of the groove may not be too sharply defined, the walls of the tooth should be bevelled down to the groove edge, and at the same time ground away over their entire surface, removing in the process a layer of enamel equal in thickness to No. 27 standard gauge, or about that of the gold plate to be used in making the crown. This will make the gold crown more nearly the exact size of the model tooth; otherwise, it will be larger by the thickness of its own walls, and the natural contour will thus be too much exaggerated.

Fig. 668.

The model seen in Fig. 665 represents the contour of the buccal wall, Fig. 666 that of the palatine wall, the cervical groove made in the model tooth being reproduced in each. Fig. 667 represents the grinding surface with sharply-defined cusps.

It will be observed that exact contour of the palatine and buccal surfaces has been prolonged laterally only to the most prominent point in the proximal curvature, the model beyond this point being built out at such an angle as will prevent an undercut and consequent breakage of the sand in moulding the die.

The dies can be made of either zinc or brass (preferably the latter), and for each there should be prepared counter-dies of lead. By the aid of these an almost perfect representation in gold of the shape of a natural tooth, and at the same time a perfect adaptation to the root, can be secured.

As teeth of the same class vary greatly in size and shape, the making of a series of such dies for each class is, of course, necessary, if the operator desires to be prepared for cases as they present themselves. The series need not, however, be very extensive; six sets for the upper molars, as many for the lower, and a corresponding number for the upper and lower bicuspids respectively, will be found ample, as the several pieces of the skeleton crown are easily susceptible of almost any modifications in their general contour necessary to adapt them to a tooth of their own type.

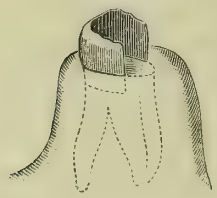
The dies are readily secured by taking in plaster an impression of the buccal and palatine half of the tooth selected as a model, this tooth being grooved at the neck and diminished in size as before directed. The impressions, being secured, are varnished and oiled and plaster run into them after the usual manner of making casts, it being desirable, for convenience in subsequent manipulations, to make the pedestals of the casts about 3 inches long, and 2 inches broad at the base, and tapering upward, so that they may readily be withdrawn from the sand in the moulding process, by which, after the ordinary methods, they are reproduced in the metallic form as dies for swaging.

Swaging the several pieces of the crown is a very simple process. In

order to determine the dimensions of the strip of gold to be used in their construction, a pattern in sheet tin is very readily secured by simply pressing it upon the die with the fingers or with burnishers. The patterns, which should be made of ample size, are reproduced in 22-carat gold, in thickness No. 27 standard gauge. By the aid of pliers, mallets, and counter-dies the palatal and buccal halves of the crown are then swaged to position upon the die and closely adapted to its surface, care being taken to press them well into the cervical grooves.

To secure ample margin for the overlap, their free ends are somewhat prolonged beyond the mesial line of the model tooth, the shape of the dies readily permitting this. As thus swaged the ends will diverge somewhat widely from the natural contour, but by placing them upon the model tooth (Fig. 668) the free ends can readily be pressed and burnished into close contact with its proximal walls, the fit at all other points being perfect if the dies have been properly constructed. As the natural tooth is liable to be broken, it is well to mount it upon a conveniently-shaped plaster pedestal, sinking the roots up to the bifurcation in plaster, and reproduce the tooth and pedestal in metal. This is most readily accomplished by making with a mixture of equal parts of whiting and plaster of Paris a sectional mould of the tooth, drying the mould until steam ceases to come off, and pouring in melted tin, Babbitt's metal, or other of the fusible alloys.

FIG. 669.



In fitting the skeleton crown to a natural root in the mouth, each half of the ferrule is separately adapted to that side of the tooth to which it belongs, as shown in Fig. 669, where the palatine half is seen pressed up under the gum. Thus placed, the adaptation of the half ring is much more readily accomplished than is that of the full ring, owing to the ease with which the sides can be compressed, and also to the greater readiness with which a full view of the interior can be obtained.

The adjustment of the palatine half being completed, the buccal half also is shaped to the tooth in the same manner, and to make the overlaps both ends of each half are allowed to extend for about the twentieth of an inch beyond the mesial line of the proximate surfaces of the tooth. The limits of this overlap should be clearly marked upon both sections while they are in position around the tooth.

The opposed surfaces of the two overlaps should then be very carefully bevelled to each other, as already directed for the single overlap in the cuspid caps. As the sections are curved upon all sides, the bevelling cannot be so readily accomplished by a file as by a small corundum wheel, which will follow all curvatures and rapidly and smoothly reduce each surface to the required extent.

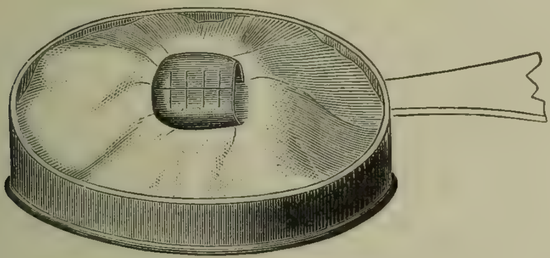
The bevels being made, the palatine and buccal sections of the crown are placed in position around the root and the overlapping surfaces adjusted the one to the other, the ends of the buccal section being spread apart sufficiently to enable them to override the ends of the palatine section, after which the two halves are pressed firmly together around

the root, while guide-lines are made along and across the mesial overlap. By aid of these guide-lines the overlaps are readjusted after the sections have been removed from position in the mouth.

To hold them together, a small clamp of iron wire may be used, but its application is often difficult, and sometimes the clamp becomes united to the gold during the soldering process. A much more satisfactory method of holding the overlapping surfaces together is to grasp them with a pair of suitably shaped spring-pliers and then partially embed the two sections in a small mass of marble-dust slightly dampened with water and contained in a small iron cup or tray.

After the marble-dust is well packed around the two sections the pliers are withdrawn and sufficient borax and water applied by means of a delicate touch from a camel's-hair pencil. With a small piece of 18-carat gold plate the joint can then be readily soldered. Care must, of course, be exercised in this manipulation, as any rude jar would disturb the adjustment of the parts. Fig. 670 shows the ferrule embedded

FIG. 670.



in marble-dust contained in the small iron tray; the guide-lines will be observed lengthwise and crosswise of the overlap. The two sections, now united into one piece, are replaced upon the tooth and the final adjustment is perfected, guide-lines being marked along the edge of the distal overlap as shown for the mesial surface in Fig. 670. In order to secure a perfectly tight fit, press the edge of the overlapping plate a little beyond the guide-line, grasp with the pliers, anneal, to counteract the tendency to spring, as explained in connection with cuspid caps, and solder as before.

Making the crown-plate and attaching it to the ferrule are comparatively simple processes. Upon the die (Fig. 667) made from the masticating surface of the model molar (Fig. 668) strike up a shell of gold; either pure gold (24-carat) or 22-carat gold will answer. The gold need not be thicker than No. 27 standard gauge; and if pure gold is used, it may be made very much thinner without danger of fusion in subsequent processes. With a very thin piece of pure gold (32 standard gauge) an almost perfect reproduction of cusps, sulci, and the finest markings on the crown can be obtained, the artistic effect being very admirable. The thicker the gold employed, the less sharply defined will be the outlines of the shell. As, however, in actual use, sharp and prominent cusps have generally to be cut down to secure proper

occlusion with their worn antagonizers, the matter is not one of much practical importance. The shell of the crown-plate should not usually extend over the body of the tooth much, if at all, beyond the base of the cusps. A good general rule is to cut the edge down almost to a level with that elevation seen on the under surface of the shell which represents the bottom of the deepest sulcus. If such alterations have been made in the outline of the ferrule that it does not correspond to the outline of the shell, the edges of the latter can readily be bent in or out, as the case may be, until they are of the proper shape. The edges of the shell should then be filed down to a uniform plane, so that when laid upon a smooth and level surface it will touch at all points.

The shell is then to be filled with 18-carat gold. To do this, place it upon the soldering support; or if the shell is very thin, embed it in marble-dust in the little tray seen in Fig. 670. Cover the inner surface with a creamy paste of borax and water and melt in, piece by piece, small squares of 18-carat gold rolled down to the thinness of No. 30 standard gauge, as the thinner the pieces, the more readily will they fuse under the blowpipe-flame. Sufficient gold is to be thus melted in the shell to fill it fully up to a level with its edge; rather above than below is the rule.

The shell, being now converted into a solid gold mass, could be united to the ferrule by the 18-carat zinc-alloy solder, and in simple crown-work this may be done; but, as we have already seen, there is in bridge-work danger of subsequent unsoldering should this method be adopted. To secure a gold crown of not less than 18 carats in fineness and made without alloy of zinc, the following method will be found simple and effective. Take the filled shell and bring its entire under surface down to an absolute level, so that when laid upon a smooth, polished, perfectly flat surface, such as the face of an office anvil, it will touch squarely at all points. If the file will not accomplish this satisfactorily, a good plan is to place the filled shell, under surface down, upon a piece of plate glass coated with emery or corundum powder and by rubbing cut away the inequalities. This being done, take a perfectly flat piece of gold of the same grade as that of which the shell was made and No. 27 standard gauge in thickness; apply borax to one surface and flow over it a film of 18-carat gold plate. This will usually make that surface a little uneven, but by passing the strip lightly once or twice through the rolling-mill, or by filing and polishing, a level surface can be obtained. This being done, the edges of the strip—or box-plate, as it may be termed—are trimmed away until they correspond in outline to the under, or filled, surface of the crown-plate, but the box-plate is at all points left a line wider. The 18-carat surface of the box-plate is then placed upon the under surface of the filled shell, previously well coated with creamy borax; the two are clamped as seen in Fig. 671 and placed, cusp-side down, upon the soldering support, and just enough heat carefully applied to fuse the 18-carat gold on the box-plate and cause it to unite with the filling, which will thus be completely enclosed or boxed in a shell of gold of a higher grade. The necessity for the nicety of jointing directed is now evident, since even a very small gap between the edge of the shell and the box-plate would afford an avenue

of escape for the 18-carat filling should it become fused in this or subsequent heatings.

For this reason great care must be taken, in fitting together the ferrule and crown-plate, not to file or cut away the protective shell or box. When, however, the ferrule and crown-plate are once united by 18-carat gold, this precaution is no longer necessary, as in all subsequent heatings the completed crown will be subjected to a temperature only sufficient to melt the gold and zinc solder employed.

Fig. 671.

Fig. 672.

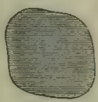


Fig. 673.

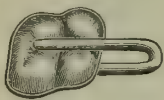


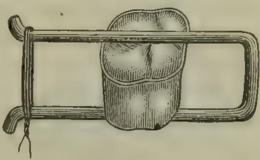
Fig. 674.

Fig. 671 shows the hollow shell, Fig. 672 the shell filled with 18-carat gold, and Fig. 673 the filled shell and box-plate clamped together preparatory to soldering. Fig. 674 is the ferrule prepared for the crown-plate.

To complete the crown all that remains is to perfect the occlusion, at the same time making a close joint between the crown-plate and ferrule, and solder them together. In making the ferrule its free edge should have been brought almost, but not quite, up to the masticating surface of the antagonizing teeth. In establishing occlusion all that is necessary is to cut away from this free edge enough gold to allow the crown-plate to slip in between it and the occluding teeth.

By filling the ferrule, while in position, with wax, taking the "bite" after the ordinary manner, and making a small articulating model, this detail can be accomplished out of the mouth even more conveniently than in it; by either method, however, the process is not difficult. In cutting away the edges of the ferrule great care must be taken that it is done uniformly, so that it will fit perfectly the under surface of the crown-plate and on such a plane as will allow the grinding surface of the crown to come in contact with the occluding tooth or teeth at the most desirable angle. The line of occlusion being established, the crown-plate and ferrule may then be joined. A clamp such as seen in Fig. 675 will hold them together, and the projecting edge of the box-plate serves as a convenient ledge upon which the small pieces of 18-carat gold plate used as a solder can rest. Frequently in fitting to place between adjoining teeth this ledge upon the proximal surfaces of the crown will necessarily have been removed, but the buccal and palatal edges need not be disturbed until the final finishing of the crown. Borax must, of course, be carefully introduced into the joint to be closed. The crown is placed upon a suitable support—preferably, the bed of marble-dust, which much lessens its liability to fall off—and by the judicious application of heat the joint can be safely and securely closed. The crown is then ready for the finishing processes. These processes consist in filing off the projecting edge of the box-plate

Fig. 675.



flush with the face of the crown, smoothing, contouring, and bevelling the free edge of the ferrule as directed for cuspid caps, and polishing with emery-powder, Scotch-stone, etc., the final polish being given by rouge carried on swiftly-revolving felt wheels. In bridge-work cases, however, all the fine finishing processes had better be deferred until the entire case is completed.

To perfect the preparation of the piers and abutments of the bridge, a slot for the bar must be cut in the grinding surface of the left molar crown. In a large percentage of cases a crown-cavity will be found in such molars; this affords a convenient point for starting the slot. Frequently but little more is necessary than the enlargement or elongation of the cavity in the mesial direction. When it is necessary to start the excavation *de novo*, it is best accomplished by means of a small corundum disk, which will rapidly make an elongated cut through the enamel, thus rendering the subsequent cutting comparatively easy. The slot need not necessarily be more than one-eighth inch long, although one-fifth inch is a better length; its depth will depend upon the position of the pulp-chamber, the sensitiveness of the tooth, the strength of its walls, and the nature of the occlusion. Its width should not exceed one-tenth of an inch, and may be less. The lower second molar tooth is frequently so much tilted in a forward direction that there is quite a considerable space between it and the mesial portion of the grinding surface of the antagonizing upper molar. In such cases quite a thick bar can be placed in position and allowed to rise above the general level of the tooth upon which it rests, the slot being made only deep enough to secure its proper anchorage. Where the bite is very close at all points, the slot and bar must be sunk deeper. The slot should be dovetailed and undercut as seen in Fig. 676. The anchorage-bar should be made of platinum alloyed with iridium, and should correspond in shape to the slot, but be made as much smaller as may be necessary to afford space for packing around it, with very fine instruments, either foil, amalgam, or cements for anchorage purposes. Fig. 677 shows a desirable shape for the anchorage-bar in the case under study. The notch on its surface, filled in with a strong packing, will fully counteract any tendency to movement in a forward direction, which might otherwise be manifested in wear.

FIG. 676.

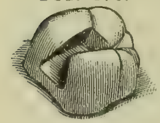
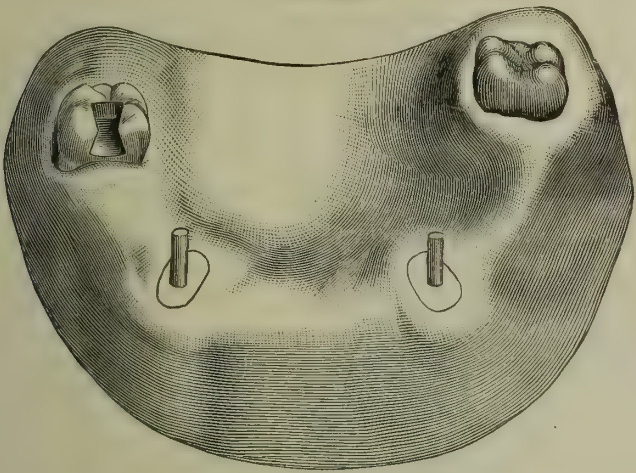


FIG. 677.

The anchorage being now fully prepared, the cuspid and molar caps are placed in position, and with plaster an impression of the mouth is taken. If the caps do not come away with the impression, they are withdrawn from the mouth and replaced in their proper position in the impression, which is then varnished or oiled, or both, and a cast run after the usual manner. After removal of the impression the caps will be found implanted in their proper positions upon the cast as seen in Fig. 678. To facilitate the subsequent removal of the cuspid caps, the inner and outer surfaces of the ferrule portions and the sides of the retaining-pins should be coated with a thin film of paraffine and wax, which by the application of a little heat will readily soften and permit the withdrawal of the caps from the cast. After the wax film has been removed the caps can

be replaced in and withdrawn from their places on the cast at pleasure. A similar method should be adopted with the molar cap. Enough wax should be placed upon its inner surface to fill out the curvatures and make its walls parallel with the long axis of the tooth. Covering

Fig. 678.



with wax the under surface of the crown-plate should, however, be avoided, as it is desirable to have that rest firmly upon the column of plaster which will be found as a part of the cast after the wax has been softened and the cap withdrawn.

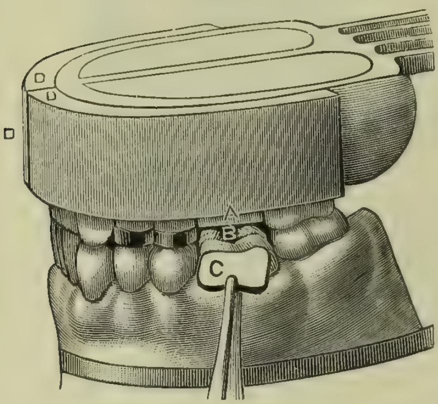
Upon the cast thus prepared a rim of wax attached to a paraffin-and-wax base-plate is modelled, preparatory to taking the articulation. The details of this process do not at all differ from the methods described elsewhere in this work. The base-plate and wax rim are made to rest upon the cuspid caps, both when they are on the cast and when in the mouth, to which they are restored when the bite is taken. At the point where the wax rim rests upon the cuspid caps it should not extend beyond their labial edge. The articulation and an impression and cast of the lower antagonizing teeth being secured, the case is properly mounted upon an articulating frame.

Suitable porcelain teeth are now to be selected and mounted. For the incisors and cuspids plain plate-teeth are usually selected; they should be strong and well made. The molars and bicuspids are built up almost entirely in solid gold, and are sometimes made throughout of that metal; but usually porcelain facings are employed, which at least serve to protect the gold from view, its conspicuousness being objectionable. For bicuspid facings cuspid teeth strongly made and with heavy pins may be used. In fitting, only the outer edge of the necks of the teeth should be allowed to rest upon the gum. The teeth should be so spaced that the cuspids will come into proper position upon the caps prepared for them. In fitting them to the caps the utmost nicety should be observed, so that there may be no space left between the tooth and

the cap. If the front of the cap is above the level of the gum, and thus exposed to view, it can often be concealed by bringing the neck of the porcelain tooth over it, using very small corundum wheels to grind out on the under surface of the porcelain a concave space adapted to the convexity of the cap; by this means the cap can often be perfectly concealed from view by a film of porcelain, which, although thin, will in that position rarely be fractured.

The teeth being fitted into position on the model, a matrix in two sections is run over their outer surface and upon the outer face of the cast, on which, as guides, conical depressions are previously cut. The matrix is seen as D in Fig. 679, The teeth can be taken from it and returned to it at pleasure—a great convenience in subsequent processes.

Fig. 679.



As molar and bicuspid facings are subjected to great strain when mounted upon a rigid and unyielding piece of bridge-work, it is generally desirable to shield them from pressure by a heavy gold crown-plate; this can be made in precisely the same manner as previously directed for making the crown-plate for the molar cap. As the shell of the crown-plate follows the dimensions of a natural tooth and molar facings are usually much narrower, it is necessary to make the shell and facing correspond in width; this is readily accomplished by bending in the edges of the shell to the necessary extent with a pair of pliers. The palato-buccal diameter of the shell should also be reduced, as it is rarely desirable to make artificial molar teeth of any kind the full size of the natural organs. The shell, being thus prepared, is filled with 18-carat gold and a box-plate attached precisely as previously described for the crown-plate of the molar tooth. The porcelain molar-facing upon which it is to rest is then ground away sufficiently to allow the crown-plate to slip in between it and the occluding teeth as seen in Fig. 679. Letter A is the porcelain face cut down at B to admit crown-plate C, which is being passed into position between the porcelain face and the occluding tooth; D is the plaster matrix which holds the teeth in position on the cast when the articulating frame is reversed. As represented in the cut they would drop out.

Too much care cannot be exercised in making the joint between the porcelain facing and the crown-plate a perfect one. For artistic effect, and also for cleanliness, there should be absolutely no space at any point. To secure this result, it is well, after all but the finest irregularities have been removed by the corundum wheel, to place a little wet pulverized corundum between the two surfaces and rub them together. This, if skilfully done, will make an almost impermeable joint.

In fitting to position, allow the crown-plate to project a very little beyond the buccal surface of the porcelain facing. This projection is to be cut away in finishing, and gives a little margin for perfecting that process.

After the same manner crown-plates are prepared for the other molars and bicuspids, which teeth are then removed from their matrices and backed with platinum No. 27 standard gauge. Each backing is made to extend from the grinding surface, where it is brought in close contact with the crown-plate, to the extreme edge of the neck, and to cover the entire inner surface of the tooth from side to side. It must be adapted to the porcelain surface with the utmost nicety. The platinum, being pliable, can be bent and burnished into the closest contact; so that the joint shall be impermeable. The proximal and cervical margins are bevelled down to a feather-edge; the coronal margin is left square. (The facing as thus prepared, with its crown-plate and backing, is seen in Fig. 680.) Cement is then placed between the crown-plate and backing and the tooth invested in the marble-dust-and-plaster mixture already recommended, preparatory to soldering the platinum pins of the porcelain facing to the backing and the backing to the crown-plate, at the same time filling in solidly with metal the angle between the latter two. It is an economy of time and labor to place three or four teeth in the same investment, taking care that sufficient space is left between them to prevent union. Invested in this manner the teeth will present the appearance seen in Fig. 681. The dotted lines seen in Fig. 682 indicate the surface to which the gold is extended in the soldering process.

FIG. 680.

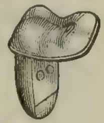
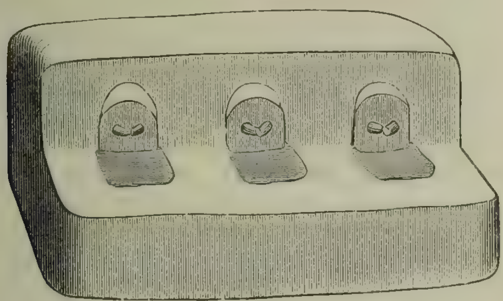
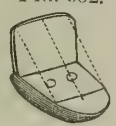


FIG. 681.



In soldering great care must be taken to secure a uniform temperature throughout the investment and its enclosed teeth: such large masses of metal are to be imposed upon the porcelain facings that unless the utmost caution is observed there is great danger of fracture. The safest plan is to heat the investment to a dull-red heat over a gas-stove or other suitable heating-apparatus, and then transfer it to a hot bed of charcoal in the soldering-furnace; by this means the heat can be raised gradually and uniformly and be maintained at the required point throughout the soldering process.

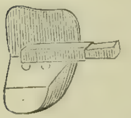
FIG. 682.



If the blowpipe-flame alone is depended upon, there is always the danger that the face of the porcelain teeth next to the metallic backing will be heated to a much higher point than that in contact with the investment, unequal expansion, followed by fracture, being pretty sure to result. With single teeth fracture in soldering does not usually depend upon too rapid heating or too rapid cooling, but rather upon unequal heating or cooling. A good porcelain single tooth protected from direct contact with flame by a suitable investment can be safely raised to a full red heat in five minutes, and cooled to the temperature of the air in as many more, provided that care be taken to make the application of the heat uniform and progressive. If a pointed blowpipe-flame at perhaps the temperature of 2000° F. is thrown upon that face of the porcelain covered by the backing, while the other, covered by a thick investment, remains at a temperature not much, if at all, above 212° F., as indicated by the still-escaping steam from the plaster, fracture is sure to result. The thicker the investment, the more difficult does it become to equalize the temperature on both sides of the porcelain tooth. For this reason it is rarely desirable to make the investment more than half an inch in thickness.

The description just given of the methods of making molar and bicuspid bridge-teeth must be slightly modified for the left molar bridge-tooth, to which the bar already shown (Fig. 677) is to be attached. To this molar the mesial end of the bar is cemented, the bar being placed against the backing and beneath the crown-plate, as seen in Fig. 683.

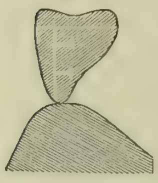
Fig. 683.



The angle between the backing and crown-plate being filled with the wax-and-rosin cement, the bar will be strongly held, and while the cement is still plastic the tooth and bar are conveyed to position in the mouth and the adjustment of the bar to the slot, and, at the same time, of the crown-plate to occlusion, is perfected. The cement is then chilled and the tooth invested and soldered as before described. The investment grasps the distal end of the bar and holds it in position after the cement has melted, while the gold solder takes the place of the cement and holds the bar firmly and rigidly in place.

Fig. 684 gives a sectional view of the completed typical bridge-tooth, that projection of the crown-plate beyond the face of the porcelain seen in Fig. 680 having been filed away to a level with the buccal surface of the facing. The relation to the alveolar ridge of the cervical edge of the bridge-tooth when in position is shown in the diagram. All exposed surfaces, except the coronal, form inclined planes upon which it is impossible for food to lodge or remain.

Fig. 684.



As the contracted cervical edge barely, if at all, touches the gum, it affords no obstacle to the flushing effect of water held in the mouth and washed to and fro under the denture. All the broader surfaces are readily accessible to a properly-constructed brush.

The molar and bicuspid bridge-teeth being completed, the cuspids and incisors also are to be backed and soldered. Platinum backings

should be used for each, and the solder should be 18-carat gold plate. In soldering the cuspids the palatine surface should be filled out to contour as seen in Fig. 685. The two cuspids may be soldered in one investment, and the four incisors in another. Upon the backing of each incisor a large excess of gold should be flowed as seen in Fig. 686, where it is made about the twelfth of an inch in thickness.

Fig. 685.

Fig. 686.

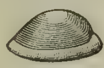
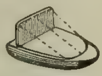


Fig. 687.



If it is found desirable to have a shoulder upon the inner edge of the incisor for occlusion with the lower teeth, this can readily be secured by cementing a strip of 22-carat gold at the proper point transversely across the backing, as seen in Fig. 687, and flowing in gold up to the dotted lines.

The several pieces of the bridge being now completed, all that remains is first to unite them into sections and then join the sections, thus constituting a continuous arch.

The first section will be composed of the right cuspid and molar abutment-teeth and the three intermediate bridge-teeth.

The second section will be formed of the left cuspid, the left molar, with the anchorage-bar attached, and the intervening bicuspids.

The third section will consist of the four incisors only.

To build the sections, the teeth composing them are restored to their several positions in the matrix upon the cast, the sides of the crown-plates and metallic backings, if redundant, being cut down sufficiently to allow the teeth to rest side by side in the matrices. It is desirable that the edges of the crown-plates should be fully in contact, but, that the backings should touch only toward the buccal surface of the several teeth, from those points to the palatine edges of the backing narrow V-shaped spaces should be left, into which the solder will readily flow and thus ensure the effectual filling up of the joint, and consequently the firm and strong union of the several teeth and caps which compose the section.

After being satisfactorily arranged in the matrix the teeth and caps are strongly cemented together with a brittle wax-and-resin cement and transferred to position in the mouth, where the final adjustments are perfected. The cement is then chilled. In this state it should be quite strong enough to hold together the several parts of the section. But usually such cements are not strong enough to withstand the strain necessarily put upon them in withdrawing tightly-fitting caps from anchorage-teeth. In such cases a thin matrix should be moulded over their buccal surface as, held together by the cement, they stand in position in the mouth. This matrix should be made of a quickly-setting plaster mixed to a thick batter. It is to be spread by a spatula over the entire front of the section, that surface of each tooth and cap composing it being fully covered, the plaster being at the same time run well into the interspaces.

After the plaster has hardened the matrix is removed from the mouth, as also are the teeth and caps. These, on being replaced in the section-

matrix, are there held in precisely the same relative positions which they occupied in the mouth.

Bridge-teeth and anchorage-caps are then very strongly cemented together and the cement thoroughly chilled, to avoid possibility of bending. The section is then carefully lifted from the matrix, invested, grinding surfaces down, in the marble-dust-and-plaster investment, and soldered with the zinc-alloyed 18-carat solder previously recommended.

FIG. 688.

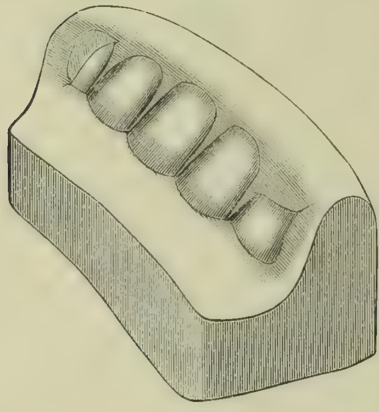
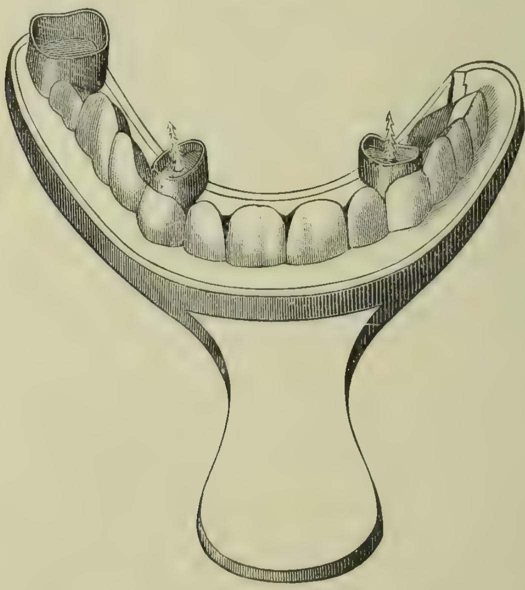


Fig. 688 shows the right section thus invested. The same methods are to be employed in forming the other sections.

Finally, the three sections must be joined, to form the continuous arch. The point of junction will be between the cuspids and laterals of either side. These two points must first be strongly cemented. This is best accomplished by thoroughly drying the right and left sections and then placing them in position in the mouth, where, by means of nap-

FIG. 689.



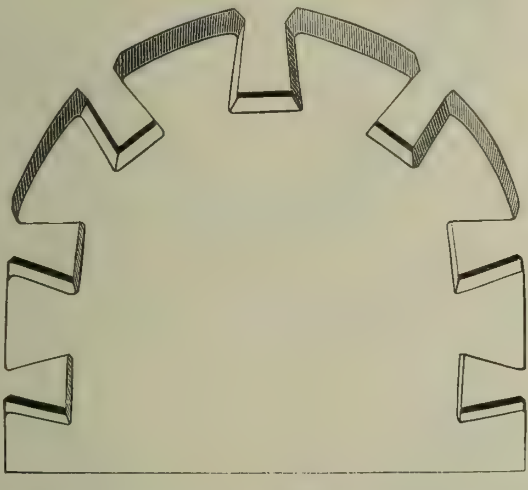
kins, they must be carefully protected from moisture. The incisor section is then also dried and slightly heated. The distal surfaces of the lateral incisors are covered with quite a thick layer of the wax-and-resin

cement, and while this is still soft and adhesive the section is carried to the mouth and pressed into place, where the cement serves to attach it to the other sections. If the adhesion is not satisfactory, it can be improved by remelting the cement with a hot iron, at the same time heating the surfaces to be joined. The cement should then be chilled.

A matrix is then made somewhat after the manner of taking an impression, the plaster being allowed to cover the teeth, previously slightly oiled, for about one-third their length above the cutting-edges and grinding surfaces, as seen in Fig. 689. The impression-tray is shallow and need contain only a small amount of plaster.

The matrix must be trimmed away until the bridge-piece can easily be detached and be replaced or withdrawn with perfect freedom. If the cement between the cuspids and laterals has been fractured, it must be again restored and hardened. The case is then with the most scrupulous care and delicacy of manipulation lifted from its place in the matrix and transferred, crown side up, to the investment-slab, seen in Fig. 690, which is designed to give a rigid and fixed support to the

FIG. 690.



bridge-piece and its investment, and thus prevent warpage of the one or fracture of the other during the soldering process.

The investment-slab is made of fireclay, about one-fifth of an inch in thickness, its other dimensions corresponding to those of the case to be invested. On its outer circumference are placed dovetailed notches made larger on the under than the upper surface of the slab. These serve as anchorages for the investment and prevent its breaking away from the case or from the slab.

In investing, these notches are filled with the investment mixture (beach-sand and plaster of Paris equal parts), and at the same time a sufficient amount of the material is heaped up upon the slab (previously placed upon a flat, smooth surface) securely to embed the bridge-piece as it is transferred from the matrix.

All parts of the case except immediately around the surfaces to be

soldered are covered with the investment, which, as already stated, need at no point be more than half an inch in thickness.

Fig. 691.

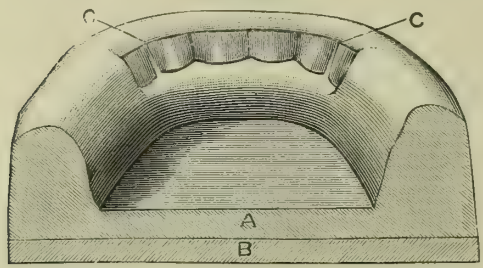


Fig. 691 shows the invested case. A is the investment; B, the investment-slab; C, C, the joints to be closed.

It need hardly be stated that in this final soldering the same care in regulating the temperature should be observed as has been previously directed. In this soldering the zinc-alloyed gold solder should be used and the joint between the laterals and cuspids on

Fig. 692.

either side be fully filled. After cooling, the case is then ready for the final finishing processes and for adjustment in the mouth.

Fig. 693.

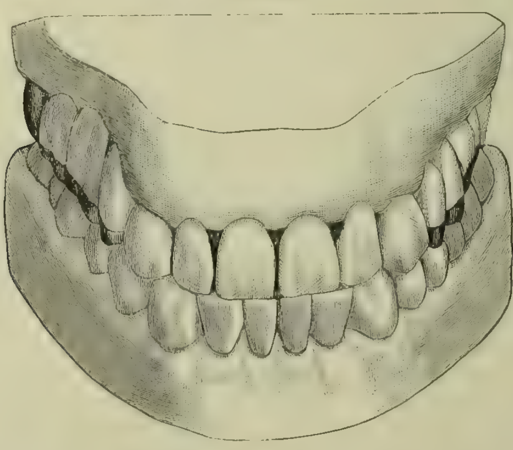


Fig. 692 shows the completed case detached, and in Fig. 693 it is seen in position.

If the directions given for the construction of the cases of bridge-work have been carefully followed, the denture after the final soldering and finishing should pass up into position in the mouth and fit with perfect accuracy. Any warpage indicates defective manipulation. This fault is readily detected by testing the case in the final matrix (Fig. 689), in which it should fit as perfectly after as before investment and soldering, except that a little excess of solder in the joints between the incisors and cuspids may cause a maladjustment at those points—a fault, however, easily discovered and remedied, either by removal of the solder or by scraping away the plaster of the matrix; which being done the case will go fully into place.

In placing the completed arch upon the anchorage-teeth some difficulty may arise in consequence of a want of coincidence in their respective angles of inclination. This is a detail which must be looked to before determining the plan of the bridge, and the case should, as far as possible, be constructed with a view to avoiding the complication, such anchorages being selected as will accomplish this end, and at the same time be satisfactory in other respects.

With every care, however, it may sometimes happen that while the individual sections are readily adjustable to their respective anchorages, they when united interlock in such a way that either removal or replacement is difficult or impracticable. This is a point which by the aid of the final matrix can and should be fully tested before the sections are united by solder; for the plaster of the matrix holds them firmly together, and if while thus held in contact they cannot be withdrawn from their respective anchorages, or, being separately withdrawn and restored to their relative positions in the matrix, they cannot be replaced upon the anchorage-teeth, it is entirely inadvisable to proceed farther until the difficulty is remedied.

Usually, this can readily be accomplished by cutting away that face or angle of the anchorage-tooth or root which is the point of difficulty. Sometimes the simple shortening of the retaining-pins, or the enlargement in a given direction of one or more of the pulp-canals, will overcome the trouble. To precisely locate the points of interference the surface of the implicated teeth or roots may be covered with a thin film of wax, or the edge and inner surface of the ferrules may be covered with a layer of rouge or plumbago, which will leave a distinct mark upon the anchorage-teeth at whatever points pressure is most considerable; which points being then cut away, the denture may readily pass into place. All remedial measures of this kind failing, some modification of the plan of construction of the denture, of a nature to simplify its anchorages, will be necessary. Devices by which this object may be effected will presently be described. (See pp. 862, 865.)

Anchorage Cements.

The adjustments being perfected and the occlusion tested, the case is ready to be finally placed in position, the caps, bars, retaining-pins, etc. being at the same time cemented to their respective anchorages. The cements usually employed for crowns and bridges are either the oxy-

phosphate of zinc or preparations of gutta-percha. Of the two, the oxyphosphate cements are much the stronger, and, when suitably protected by metallic coverings, have in the mouth an indefinite durability. Their great disadvantage is that, once hardened in the mouth, they cannot again be rendered plastic, so that when they have been employed the removal of a deeply-anchored dental bridge from position is an extremely difficult matter. Gutta-percha, on the contrary, is readily softened by heat, and, this being done, the bridge is as readily detached from its anchorages. The disadvantage connected with the use of gutta-percha for bridge-work is that it is not sufficiently rigid to resist the strain put upon it by a large dental bridge, the leverage in such cases being considerable. For the temporary attachment of bridges, however, it serves a good purpose, and the writer finds it to be a good plan to test the adaptation of large bridge pieces by using this form of cement and subjecting the case to actual wear in the mouth before permanently cementing it with oxyphosphate.

For single ferrule or collar crowns the writer always, when practicable, employs a gutta-percha cement in preference to the oxyphosphate preparations.

The conditions necessary to success with gutta-percha are that the roots shall be large and strong, the ferrule or collar of the cap broad and firm in its grasp of the root, and the retaining-pin sharply barbed and at least two-fifths of an inch in length, with a thickness at its largest part of No. 13 standard gauge. Given these conditions and a good gutta-percha packing, and the attachment will be amply strong. To secure this result the length of the retaining-pin is the most essential factor. A short pin, which would be firmly held by the stronger oxyphosphate cements, would be very insecurely grasped by the more pliable gutta-percha. If, however, the pin is lengthened and well barbed and the pulp-canal is transversely grooved, then the surfaces of adhesion become ample, and the displacement of the pin without a previous softening of the gutta-percha packing becomes a matter of great difficulty.

It must further be remembered that when a cap with a ferrule or collar is employed nearly the whole office of the retaining-pin is to hold or assist in holding the case *in situ;* that is, to resist the force of gravity. It can be subjected to but very slight transverse strain, as nearly all the force employed in mastication must fall through the ferrule and crown-plate of the cap either upon the crown surface or the periphery of the root, or upon both. Hence the security of the appliance.

For molar caps in cases such as that represented in the model, gutta-percha is not well adapted, the surface which the ferrule can grasp being so restricted; furthermore, the filling of the entire interior of the cap with any of the gutta-percha stopping materials is objectionable, for the reason that they are all porous, and soon become charged with organic fluids in a state of decomposition, with the result of imparting a very unpleasant taste to the mouth. This is not often noticeable with oxyphosphate preparations, although they also are far from being aseptic after they have been in the mouth for any considerable length of time; this being true whether they have been in use simply as stoppings or as cements. For the reasons given it may then, in general terms, be stated

that in cases analogous to the one represented in the model an oxyphosphate-of-zinc cement is to be preferred for all the anchorages. It is well, however, to place a thin layer of gutta-percha between the anchorage-bar and the floor of the slot in which it rests.

Mixing the Cement.

The oxyphosphate cement used should be of the best possible quality, and should not set too rapidly. For mixing purposes a perfectly smooth and flat slab of thick plate glass four inches square, and a thin, elastic steel spatula about six-tenths of an inch wide, should be used. Concave surfaces and narrow, rigid spatulas are objectionable, for the reason that they do not enable the operator to bring the acid and oxide together with nearly so much rapidity and precision as when in mixing a broad spatula is used as a muller upon a flat surface.

The consistency of the cement is a matter of great importance. If made too thin, it will lack stability; if too thick, it will pack with difficulty, or may entirely prevent the forcing of the cap into position. What is required is a viscid, adhesive mass of about the consistency of the richest cream. The relative proportions of zinc oxide and phosphoric acid necessary to secure this result will vary with each specimen employed: it is impossible to give any fixed rule, skill in the process being attained only by observation and experience. In mixing, the requisite amount of acid and oxide are placed separately upon the slab, and are then ready to be brought together and thoroughly commingled, the acid and oxide bottles being left open, so that additional quantities of either may be added if found necessary to secure the proper result.

As those chemical changes upon which the setting or hardening process in oxyphosphate cements depends begin from the moment the oxide and acid are brought in contact, the utmost expedition in manipulation is necessary. All instruments requisite for mixing and packing the cement should be conveniently placed; the anchorage-teeth and roots should be thoroughly dried, as also should the artificial denture. Through the crown-surface of the molar cap a small opening should be drilled to serve as a ventage for the surplus cement. This precaution is not necessary with the cuspid caps, as they are comparatively so shallow that the surplus will readily escape from around the ferrule. The retaining-pins of the cuspid caps should be barbed, with the points looking away from the apex of the root; but the barbs should not be too prominent or they will prevent the pins from passing into the pulp-canals. The walls of the canals should be transversely grooved to give additional security to the cement. This grooving is best accomplished by means of a small right-angled hatchet excavator. The grooves need not be very deep or very numerous, but their edges should be sharply defined.

Everything being in readiness, the cement is mixed, and packed rapidly into the caps until they are completely filled, care being taken to exclude air-bubbles. The retaining-pins of the cuspid caps are at the same time well covered, and the walls of the pulp-canals are coated with a layer of the cement. The denture is then instantly pressed into position, and held there until the cement has somewhat hardened. Care should be taken

to examine the points of contact between the gum and the denture, in order to determine whether the case is fully in place. The occlusion also should be tested before the cement has so much hardened as to prevent the ready withdrawal of the denture should that be found necessary.

The cement having hardened, and the surplus cement having been removed from around the caps, all that remains is to pack either gold or amalgam in the space between the anchorage-bar and the walls of the slot. For this use amalgam is, as a rule, to be preferred, as the space can usually be more readily and securely filled by it than with gold, while contact with the platinum promotes surface oxidation and prevents leakage. The blackening of the amalgam is the only objection to its use, as when well packed the amalgam is in practice found quite perfectly to protect the walls of the slot from decay. When discoloration would be conspicuous gold may be substituted. The protection of the floor of the slot by a layer of tough gutta-percha has already been directed.

Where the anchorage-bar attachment has been employed, it is always desirable to leave a little space between the bridge-tooth and the anchorage-tooth, so that a full visual examination of the condition of the walls and floor of the slot may at any time be made. The space has the further advantage of promoting cleanliness, and of thus preventing decay. The presence of the anchorage-bar bridging across this interdental space effectually prevents food from being forced against the gum in the act of mastication.

When single crowns are to be attached with gutta-percha, a preparation should be employed which, while possessing a good degree of toughness, will at a moderate heat become sufficiently plastic to yield readily under pressure. In using gutta-percha as a packing the barbed retaining-pins are well covered with the material, which should be pressed upon and moulded around them until it firmly adheres. An excess of gutta-percha should be prolonged in a thin, tapering form beyond the end of the retaining-pins, thus more fully ensuring the complete filling of the pulp-canals, the apical foramen of which should previously have been closed with the same material. The gutta-percha should be packed not only around the pins, but also upon and around the inner surfaces of the ferrule or collar, using here too a considerable excess of the material.

Preparatory to cementing the denture into position the caps and pins are well heated either over a water-bath or by the flame of a spirit-lamp or Bunsen burner; if the latter method is employed, avoid bringing the gutta-percha into prolonged contact with the flame. Passing gutta-percha rapidly to and fro through a flame will soften it quickly, and without carbonizing it or in any way injuring its texture. When sufficiently heated (a temperature a little hotter than is comfortable for the fingers is required) the crown is with a firm, steady, progressive pressure forced into position upon the root (previously thoroughly dried), care being taken that it is pushed fully into place. The surplus gutta-percha which will ooze from the margins is then cut off with heated instruments, the edges being afterward smoothed by pass-

ing over them a pledget of cotton dipped in chloroform. The end of a pulp-broach covered with a film of heated cement is a good carrier for the cotton, which should be wrapped around it. Even a smooth broach thus armed with cement will hold the cotton very firmly.

Removal of Crown- and Bridge-Work.

When the attachments of a deeply-anchored bridge have been cemented with oxyphosphate of zinc, more or less marring of the caps is generally necessary for their removal. A considerable weakening of the attachments can usually be effected by passing through the small opening made in the masticating surface of the cap an inverted cone-burr, with which the mass of the oxyphosphate can be loosened or cut away. If after this the cap cannot be forced from its position around the root, division and spreading of the ferrule will be necessary. A single cut through that portion of the ferrule which grasps the root will be sufficient. This is readily effected by means of a strong, sharp knife-blade, and, once divided, the ferrule can be pushed away from around the root to any required extent. Once separated from the tooth and the cement removed, it is very easy to bring together the cut edges and solder them, the cap, if properly readjusted to the root, being as serviceable as before.

If the cuspid caps have been attached with oxyphosphate, not only may it be necessary to divide the ferrule, but also to sever the connection between the retaining-pin and the base-plate, the cement being subsequently cut away from around the pins by means of suitably-shaped burrs and drills. This process of course necessitates not only a resoldering of the ferrule, but also of the retaining-pin to the base-plate.

When single crowns have been cemented with gutta-percha, that substance can readily be softened by means of relays of heated instruments applied to the metallic surfaces of the crowns; and when softened the gutta-percha offers no further obstacle to their withdrawal from position. This facility of removal, when combined with stability in wear, is of the greatest possible advantage; for the fact should never be lost sight of that at any time removal may become desirable or necessary, either for the treatment of pathological conditions of the natural root or for the repair of the artificial crown.

Repair of Crown- and Bridge-Work.

Repair of Single Crowns.—The repair usually required for single crowns when mounted with a ferrule or collar is replacement of the facing, and when properly mounted in mouths well supplied with natural teeth even this is not often demanded. The splitting of a root well grasped by a strong ferrule is wellnigh impossible. After the removal of the cap from the root by means previously described, the most expeditious plan of repairing a broken facing is to remove it with its backing from the cap, and replace it with another tooth, soldering and cementing in position as before. When it has been found necessary

to detach the cap from the retaining-pin, this must of course be replaced, generally by a new one.

Repair of Bridge-Work.—As with single crowns, the repair most frequently called for in bridge-work is the replacement of fractured porcelain facings. When the case has been made readily removable from the mouth by the use of surface anchorages (see p. 862), this form of repair presents but few difficulties. All that is necessary is to duplicate the facing, back it with thin platinum, fit it into the position occupied by its predecessor, invert, and solder from the under surface, being careful to leave between the two metallic surfaces to be joined a narrow V-shaped space into which the eighteen-carat gold-and-zinc solder to be employed will readily flow.

For the restoration of facings, the bridge-denture remaining *in situ*, Dr. Williams[1] suggests the following plan:

"After removing all traces of the broken porcelain, the projecting pins are cut off, and two holes drilled through the backing in the exact position occupied by the pins. The narrow space of metal now intervening between these two holes is cut out with a fissure-burr. This leaves a groove which should not be wider than the diameter of the pins. The length of this groove should now be increased on the lingual surface, but not on the front. The object of this is to give a dovetail shape to the groove, which is easily effected by the use of the same fissure-burr above referred to. The lingual appearance of this groove when properly shaped is shown in Fig. 694. The proper tooth is selected, the pins passed through this hole and bent outward into the dovetail groove. It will be found almost impossible to bend these pins into their proper positions by any ordinary means, so as to hold the tooth quite rigid and immovable. An instrument herewith illustrated (Fig. 695) accomplishes this feature of the work in a very simple and effective manner. Its use is almost too nearly evident to require description. Both the rubber pad which rests upon the porcelain front, and the wedge-shaped point which passes between the pins, are made to rotate in their sockets, so that any desired position can be obtained. A firm closure of the instrument when in position forces the pins outward into the dovetail groove, and the tooth is immovably fixed in its place. It now remains but to fill the space between the pins with any form of cohesive gold (I use crystal gold), and with corundum, Arkansas, and rubber points in the engine the surface is finished and polished. The wedge-shaped filling of crystal gold acts as a

FIG. 694.

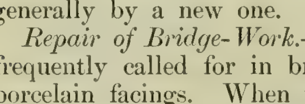
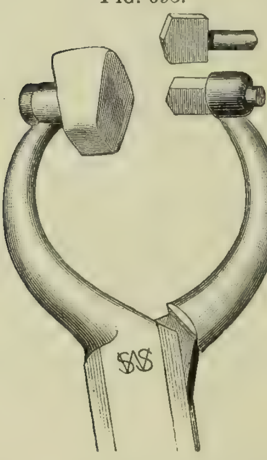


FIG. 695.



[1] *Dental Cosmos*, December, 1885.

keystone between the pins and makes a most perfect method of repair."

Fig. 696 illustrates a more recent device of Dr. Williams for replacing a fractured facing in a bridge-denture. In the backing of the lateral incisor a grooved slot has been cut, into which groove the metallic attachment of the facing is made to slide and fit tightly. It may be secured in position either with gold or with an oxyphosphate cement. This plan is substantially the same as that of Dr. Wardwell, for description of which see p. 881.

Fig. 696.

To lessen the liability of breakage in porcelain teeth Dr. Williams has more recently suggested the plan of cutting with a corundum disk a groove along the sides and across the base of the tooth, as seen in Fig. 697, and also in cross-section in Fig. 698. This groove should be deep and broad enough to hold a platinum wire of not less than No. 20 American gauge in thickness. Into this groove and over the back of the tooth is closely pressed a piece of platinum-foil of suitable size, thus forming the shell seen in Fig. 699. This, when fully adapted to the tooth, is clamped in position by the staple of platinum wire seen in Fig. 700.

Fig. 697.

Fig. 698.

Fig. 699.

Fig. 700.

Fig. 701.

Fig. 701 represents the appearance of the tooth as thus prepared. It is then invested, leaving exposed the whole surface covered with platinum, and twenty-two-carat gold is flowed in around the staple and over the whole surface of the backing until a sufficient thickness has been secured to make the attachment strong and resisting.

In the figures just given the platinum pins usually placed in porcelain teeth have been dispensed with. Figs. 702, 703, 704 show grooved teeth in which they have been retained. Fig. 705 shows in cross-section a tooth with both pin and groove. The presence of the pins is not considered by Dr. Williams as essential to stability, but they do not materially weaken the tooth, and are a convenience in that they aid in holding the platinum-foil in position during the process of its adjustment to the tooth.

Fig. 702.

Fig. 703.

Fig. 704.

Fig. 705.

The method of clamping teeth as above illustrated has been tried to a limited extent by the writer, and with satisfactory results. While the plan is of too recent introduction to justify a final verdict upon its merits, it is obvious that in many cases it will materially add to the

strength of porcelain facings. Unfortunately, in the incisor teeth it is difficult to apply the clamp support without exposing to view its metallic surfaces.

Drs. Low and Matteson suggest the use of porcelain shells placed in metallic sockets. Representations of these devices are given on pp. 913, 933.

Where the "bite" is short and the occlusion strong the writer prefers to make all molar teeth, and sometimes the bicuspids, of solid gold. This is readily accomplished by fitting to the space to be filled crown and buccal shells (see pp. 840, 845) of twenty-two-carat gold, cementing them together, and investing and filling with eighteen-carat gold, in the same manner and at the same angle as though the buccal shell were of porcelain. (See Fig. 682, p. 349.) A tooth thus made is practically indestructible, and if placed back of the first bicuspid is usually not unsightly. For dramatic artists, singers, and public speakers, however, for whom bridge-work is of such inestimable value, strong and durable full porcelain crowns, as well as facings, are much needed, as the glare of the footlights brings into disagreeable conspicuousness the glitter of exposed metallic surfaces both in crowns and in bridge-dentures. The inherently fragile nature of porcelain would, however, in a majority of cases, seem to present an impassable barrier to its successful employment except when strongly guarded by metallic supports, which of necessity are to a greater or less extent unsightly and destructive of artistic effect.

For this reason the writer has endeavored in all cases to so simplify the attachments that the entire appliance can be removed with the minimum expenditure of time and labor. This is desirable not only for purposes of repair, but for the further reason that removal may at any time be demanded for the treatment of pathological states of the natural teeth or roots embraced by or attached to the artificial denture. Conditions demanding treatment are constantly arising in teeth entirely dissociated from bridge-work dentures, and must occasionally be expected when they are made to serve as bridge anchorages.

Surface Anchorages.

An anchorage for cuspid roots which the writer has found to be in suitable cases simple, effective, and accessible consists of a ferrule crown-plate and barbed retaining-pin made in the usual manner, after which the inner or palatine half of the ferrule is reinforced by a strip of twenty-two-carat gold, in thickness not less than No. 16 standard gauge, which is so placed that its free edge shall be on a level with the edge of the crown-plate. The surface toward the gum should be bevelled to a thin edge, to avoid an abrupt shoulder at that point. When properly soldered to the ferrule, this added strip enlarges by its own width the area of the palatine half of the crown-plate.

The purpose of this enlargement is to make room upon the surface of the cap for a retaining-post of sufficient thickness (No. 9 standard gauge). This post is preferably made of platinum-iridium alloy; its most desirable shape is that of an inverted truncated cone. As a rule, this post cannot be made continuous with the retaining-pin, but, to

make room for the porcelain tooth and its backing, must be set a little nearer the palatine edge of the crown-plate.

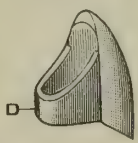
The porcelain facing selected for the case must be properly aligned and set in position on the cap, to which, after being backed with platinum, it should be tightly cemented. The cap should then be imbedded in plaster up to, but not beyond, the edge of the ferrule, a little plaster being at the same time placed in front of the porcelain facing to form for it a matrix to hold it in its proper relation to the cap.

A heavy half-ring made of platinum-iridium alloy, in thickness No. 16 standard gauge, is then so shaped that its outer edge will be flush with the outer edge of the flange which has been soldered to the ferrule. Upon this flange it should be made to rest squarely, the open ends of the half-ring resting against the backing of the porcelain facing, to which, ultimately, it must be soldered.

The platinum-iridium half-ring being made, its outer surface is faced with a strip of twenty-two-carat gold, No. 28 standard gauge in thickness. The strip of gold is made not only to cover the half-ring, but to extend beyond its upper margin sufficiently to overlap the flange of the ferrule to a slight extent. When properly fitted the half-ring and its gold facing are soldered together with eighteen-carat gold.

The half-ring being completed, its ends are cemented to the backing of the porcelain facing, and the half-ring and facing are then invested in such a manner that they will be held from the outside, their inner surface being exposed to view, so that by a suitably-directed flame the pins may be soldered to the backing and the backing to the half-ring, an abundance of solder (eighteen-carat gold plate without zinc) being used to give the utmost possible strength to these soldered surfaces. Fig. 706 shows the half-ring, D, with the porcelain facing attached.

FIG. 706.



By this addition of the porcelain facing to the half-ring a complete ring is formed. In shaping this ring care must be observed that a little space is left between its inner surface and the outer surface of the post on the cap. The inner circumference of that edge of the ring which rests upon the cap should be a little less than the inner circumference of the free edge of the ring.

FIG. 707.

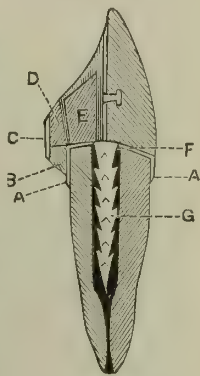


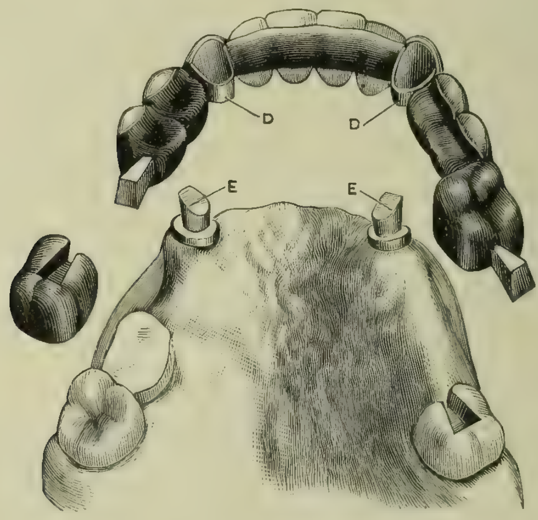
Fig. 707 shows the anchorage as thus prepared: A represents the ferrule attached to the cuspid root; B, the flange soldered to its palatine half; C, the gold facing of the platinum half-ring slightly overlapping the flange of the ferrule (this aids in holding the ring in position upon the cap, and also protects the cement from wear); D, the platinum half-ring resting squarely upon the flange of the cap; E, the anchorage-post soldered (with eighteen-carat zinc-alloyed gold solder) to the crown-plate of the cap (F), the location of the post being, as is seen in the diagram, a little to the palatine side of the position of the retaining-pin (G), this being made

necessary by the fact that in practice the base of the porcelain tooth usually comes to the edge of, if it does not entirely cover, the retaining-pin at the point where it is soldered to the crown-plate, there being, of course, under these conditions no room at that point for the placing of an anchorage-post of suitable size.

In using this form of anchorage the cap, held by its retaining-pin and surmounted by the anchorage-post, is first cemented in position upon the root by means of an oxyphosphate cement. The anchorage-ring, with the porcelain facing attached, is then filled with the same form of cement and pressed into position upon the cap and around the anchorage-post. The cement, when hardened, being firmly held in place between the cone-shaped surfaces of the post and ring, effectually prevents the displacement of the latter. This, as compared with the attachment of the cap to the root by means of the retaining-pin, may be termed a surface anchorage, and has been so designated. This form of anchorage was first employed by the writer in the year 1880, the case being a bridge-denture embracing the upper six anterior teeth.

In the case of bridge-work illustrated in Fig. 708 this anchorage has

FIG. 708.



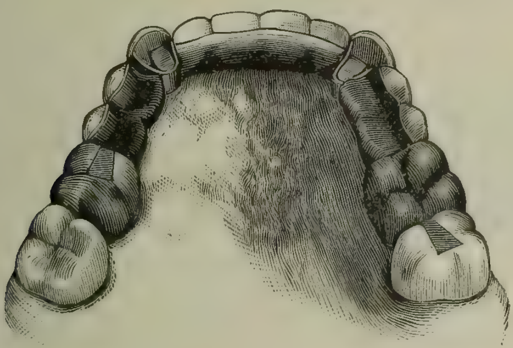
been utilized for each of the cuspid roots, the caps, surmounted by the anchorage-posts (E, E) being seen in position, while at D, D are seen the porcelain-faced anchorage-rings, to which have been strongly soldered the three sections of the bridge-denture—namely, a molar and two bicuspids on the left, two bicuspids on the right, and the four incisors centrally.

In this case the bridge has been attached to each of its molar supports by surface anchorages. In the natural molar crown on the left the ordinary slot and bar have been employed, while on the right the molar anchorage-root has been crowned by a slotted metallic cap, this

being simply the usual form of gold crown, in the coronal surface of which a metallic slot has been sunken for the reception of an anchorage-bar. Thus when the cap has been cemented upon the root it is without direct connection with the bridge, but through the slot forms a secure surface anchorage for the right anchorage-bar of the denture.

As may readily be seen, the advantages of these forms of surface anchorage consist, first, in the ease with which the completed bridge-denture may be adjusted to position in the mouth; and second, the readiness with which it may be detached and replaced. With fine drills or excavators the cement can in a few minutes be cut from around the anchorage-bars and posts, after which there is no further obstacle to the removal of the denture should removal be desirable or necessary. As none of the attachments need be injured in removal, replacement is of course equally easy.

Fig. 709.



In Fig. 709 the denture is seen in position, the cuspid anchorage-posts embraced by the anchorage-rings, the left anchorage-bar resting in the slotted molar, the right in the slotted metallic cap shown in this figure as cemented upon the root.

In metallic slots, as metallic surfaces only are in contact, and as the joint between slot and bar can be made very close, there is often no absolute necessity for the employment of anything but the oxyphosphate cement. If the joint is large, however, it may be filled in with gold or amalgam.

For the cuspid teeth it is well to cut out a little of the cement from around the anchorage-posts and pack gold-foil in its place. This protects the cement from wear and secures a smooth and uniform metallic surface. The manner of preparing anchorages in slotted natural crowns has already been described. (See p. 857.) Slotted metallic caps have been frequently employed by the writer during the past two years, and with entirely satisfactory results. In forming them the best plan is to make a model of the slot in the form of a thin shell of platinum, lightly solder it in its proper position upon the crown-plate of the cap, and then fill in with gold the space between its outer edge and the platinum shell.

THE PIN-AND-PLATE BRIDGE.

This form of bridge, originally devised by the writer for use in connection with incisor teeth,[1] to which it is more particularly applicable, has also its uses in combination with those other forms of bridge-work already described, and which may be distinguished as crown-and-bar bridges.

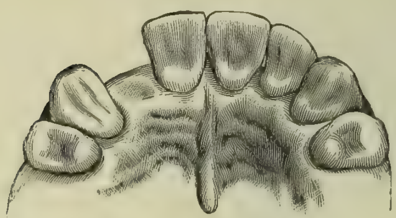
For the illustration of the method of constructing a pin-and-plate bridge for an incisor tooth, Fig. 710 may be taken as representing a typical case. The lateral incisor of the right side has been lost, and the cuspid and front incisor, fully vitalized and without proximal carious cavities, remain in position.

The various steps in the process of construction are as follows:

1. Take in plaster an accurate impression of the cuspid and incisor and the interspace. From this obtain a plaster model of the parts.

2. Make from pure gold, rolled to the thinness of 26 standard gauge, base-plates to be carefully adjusted to the palato-proximal surfaces of the cuspid and incisor. These can be made by swaging on dies and counter-dies obtained from the model, but more conveniently by bending the gold into shape upon the plaster model, and pressing and burnishing it into perfect adaptation upon the natural teeth.

FIG. 710.



3. Select a plain plate porcelain tooth of suitable length, shape, and shade, and wide enough to fit easily into the interspace. Let the neck of the tooth rest lightly upon the gum.

4. With pure gold or platinum make a backing for the porcelain tooth.

5. Place the tooth thus prepared and the base-plates already made upon the cast, and accurately adjust the proximal edges of the base-plates to the backing of the porcelain tooth *in situ* upon the cast.

6. When this adjustment is made cement together the base-plates and backing with a brittle resinous cement (resin, two parts; wax, one part—sealing-wax or shellac will answer), and before the cement has fully hardened remove from the cast to position in the mouth, perfecting the final adjustment there. By this method much greater accuracy of adaptation is obtained, as the lines of length, width, and contour are too fine to be reproduced with absolute fidelity in a plaster model. In this part of the process too much care cannot be taken to have each piece of the appliance fitted with absolute accuracy to the surface for which it is designed. When this has been accomplished throw upon the yet more or less plastic cement a stream of ice-cold water from an office syringe: this renders the cement perfectly brittle and incapable of bending. This done, immediately remove from the mouth and

[1] See *Dental Cosmos*, August, 1880, and March, 1886.

invest in a mixture of equal parts of marble-dust and plaster of Paris.

7. After the investment has firmly set solder the base-plates to the backing, and the backing to the platinum pins of the porcelain tooth, using as a solder twenty-carat gold. Thus joined, the appliance will present the appearance shown in Fig. 714—A representing the base-plate for the cuspid; B, the base-plate for the incisor; C, the porcelain tooth with its platinum backing; D, the points of union between the base-plates and backing. At these points the greatest strength is required, and it is important that here a large amount of the solder should be placed. The porcelain tooth being usually thinner than the natural teeth, there is nearly always an angle or depression at the points indicated, in which the thickness of the gold can be considerably increased without interfering with occlusion.

8. For the purpose of attaching the denture as thus far constructed, drill a small cylindrical opening through the palatal surface of the enamel of the cuspid and incisor respectively. These openings should usually be placed about as indicated in Fig. 713, at C D. Sometimes, owing to a close occlusion or to the contour of the tooth, it is desirable that they should be located a trifle nearer the neck of the tooth. Each opening should be well undercut, but must not encroach upon the dentine far enough to endanger the pulp. In size the openings need not be larger than will admit a platinum pinhead in diameter corresponding to 13 standard gauge, with a shank of 18 standard gauge. Into each of these openings must be fitted a platinum pin of the size indicated. The head of each pin must be made thin and perfectly flat both upon its upper and under surfaces.

9. In each of the base-plates make an opening corresponding in position to those in the natural teeth. Pass through these openings and cement in them the free ends of the platinum pins. While the cement is yet plastic place the denture in position in the mouth, carefully pressing the pinheads into the openings made for them, and burnishing the base-plates into perfect contact with the palatal surfaces of the teeth; chill the cement, remove and invest as before, and with twenty-carat gold solder the pins to the base-plates, flowing upon them and the backing as much of the solder as may be necessary to give them the desired thickness and rigidity, the amount admissible largely depending upon the nature of the occlusion; a central thickness of about 21 standard gauge being all that is really requisite for strength, while the edges can be made much thinner.

FIG. 711.

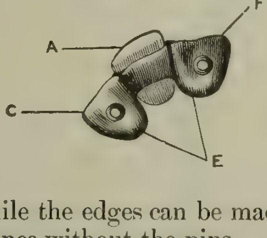


FIG. 712.

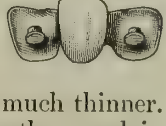


Fig. 711 represents the appliance without the pins. A is the porcelain tooth and backing; E, the base-plates; C and F, the openings for the pins.

Fig. 712 represents the appliance completed with the pins in position.

Fig. 713 represents the natural teeth and interspace B, with openings for retaining-pins C D.

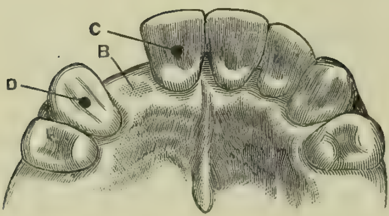


Fig. 713.

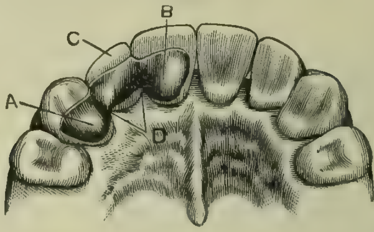
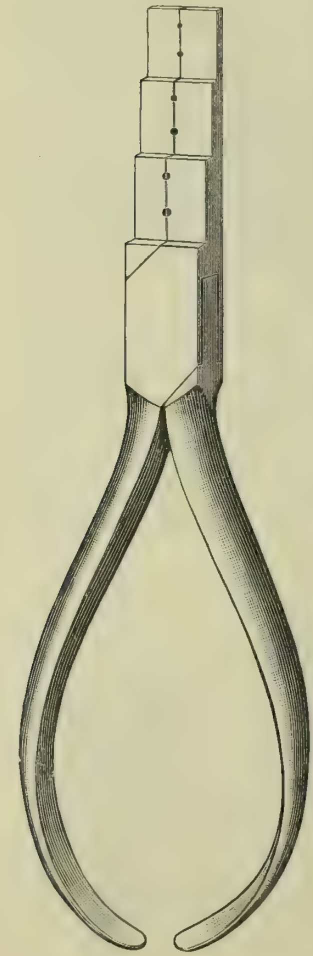


Fig. 714.

Fig. 714, already described, represents the appearance presented when the bridge is cemented in position.

To form the platinum pins required for this and allied processes the tool represented in Fig. 715 will be found effective. It consists of a pair of pliers with highly-polished steel beaks, having cylindrical openings between them, which openings are of several sizes in order to adapt them to different sizes of wire. In order that the wire selected may be firmly grasped by the beaks, the wire-hole must be a little smaller than the wire itself. To still further strengthen the grip of the tool upon the wire, its beaks must be firmly pressed together within the jaws of a vise. A sufficient length of wire to make a pinhead is left projecting through the wire-holes, and the head is then formed by blows from a small hammer. When a double pinhead is desired, the wire can be cut off at a suitable distance from the reverse side of the tool, upon which side the other head of the pin can be formed in the same manner as was the first. It will be observed that from joint to ends the beaks diminish in thickness, forming three successive steps. This enables the operator to make double-headed pins in three different lengths.

Fig. 715.



To Attach the Bridge.

To attach the bridge the best attainable oxyphosphate cement should be used. It is desirable that it should set slowly. Thoroughly dry the teeth and denture; mix the cement to as thick a consistence as is compatible with perfect plasticity. A thick, viscid, semifluid mass is what is required, a thin cement, such as may be produced by an excess of acid, being too

unstable to give satisfactory results. With suitable instruments swiftly but carefully place the cement around the head and shank of each platinum pin and also in the openings in the natural teeth. This care is necessary in order to exclude all air-bubbles and thoroughly engage the pinheads in the cement. They furnish ample retaining surface, but none to spare. In packing the cement around the pins the under surface of the base-plates should at the same time be covered.

The above details being perfected, the denture is at once carried to position and with broad-pointed, serrated instruments pressed firmly into place, the excess of cement, if of the proper consistence, freely oozing at all margins.

Too much care cannot be exercised in the cementing process. As every second of time is of value, all instruments required must be selected and conveniently placed before the oxyphosphate is mixed, the slab and spatula already described (see p. 857) being employed in mixing.

A very troublesome obstacle to success in the use of the oxyphosphate cements will often be found in the temperature of the air, an elevated temperature so hastening those chemical changes upon which the hardening of these cements depends as to render their use almost impracticable. This difficulty is likely to occur only in the hotter seasons of the year, and can readily be overcome by placing the mixing-slab, as well as the acid and oxide bottles, in cold water until their temperature has been considerably reduced.

During severe winter weather too low a temperature also gives trouble, the acid and oxide, even when the former is in some excess, forming a powdery mass utterly unworkable, but which melts down into an almost fluid condition when brought into contact with the warmth of a tooth *in situ*. A temperature between 60° and 65° F. secures the best results in mixing oxyphosphate cements.

Application to Pulpless Teeth.

In the above description the vitality of the pulps of the cuspid and incisor has been assumed, but, as can readily be understood, the pin-and-plate bridge can be even more readily and securely placed when one or both pulps are devitalized, for the reason that, the pulp-chamber being empty, the pinholes in that tooth can be made as much larger and deeper as may be deemed desirable, the size of the pin being of course correspondingly increased. In a devitalized tooth, too, the base-plates can be sunk into the palatine surface when they interfere with occlusion, as sometimes happens when the antagonism of the lower teeth is very close and the overlap is considerable.

Ordinarily, however, such interference is inconsiderable, and the difficulty can always be overcome, either in devitalized teeth by the expedient just suggested or by carrying the base-plates as far away from the cutting edge as practicable, at the same time making them at the point of contact as thin as is consistent with strength; finally, if necessary, removing a slight portion of the cutting edge of the occluding lower tooth.

As experience with this as well as other forms of bridge-work has fully demonstrated, a slight mutilation of a natural tooth is far less destructive in its ultimate results than is the wearing of partial plates, and it may be safely affirmed that in all applicable cases the pin-and-plate bridge accomplishes its purpose with the minimum of injury to the natural organs.

The small size of the retaining-pins may excite doubts as to the strength of the denture; but pins smaller in size are constantly used for attaching porcelain teeth to plates, and in the upper incisor series these pins are much less advantageously placed for resistance to pressure than are those imbedded in the natural teeth in the process above described.

The weakest point in the bridge is not the pins, but the cement; but this, while not so strong as the fused porcelain which surrounds the pins in artificial teeth, is, as experience has demonstrated, just strong enough to resist all ordinary wear and tear, without being so intractable as to render the removal of the denture for purposes of repair a practical impossibility by any method short of its destruction.

Even with a good oxyphosphate cement the work of removal is one of no slight difficulty, and requires the exercise of so considerable an amount of force that no one who has had occasion to perform that operation will question the security of any well-constructed specimen of this form of bridge. During an experience of some seven or eight years in their use the writer has had but one or two cases in which the appliance became loosened, and only one in which it was detached outright. In the latter case the bridge (constructed with the natural tooth of the wearer instead of a porcelain substitute) had been firmly in position for more than a year, when the sudden wrench consequent upon biting into a very hard peach detached it. Being immediately replaced, it has since then (some three years ago) done good service. In such cases it is usually advisable to slightly deepen the undercuts in the pinholes before replacing.

Repairing.

For the pin-and-plate bridge the least difficult method of repair is to separate the tooth and backing from the base-plates by means of a watch-spring saw, and then force off the base-plates singly, this being much more easily accomplished than their removal when united to the backing. Another tooth is then selected, fitted, backed, and soldered as before.

As a rule, the writer has confined the use of this form of bridge to cases in which only a single incisor is missing, but he has successfully attached a front and lateral incisor to a cuspid and the remaining front incisor. Where an unusual strain is to be expected the retaining-pins and pinholes should, when practicable, be made correspondingly large, or two smaller pins may be anchored in one tooth, which latter plan gives very great resisting power and renders removal in the highest degree difficult and laborious.

Porcelain Tips.

Figs. 716, 717, and 718 show how the pin-and-plate process may be utilized for the attachment of porcelain tips for broken or decayed

Fig. 716.

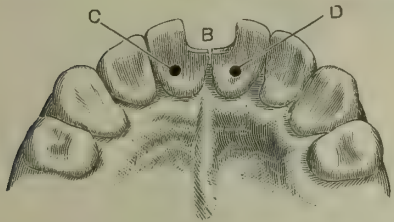


Fig. 717.

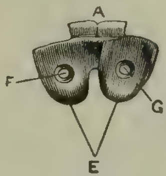


Fig. 718.

incisors when the appearance of gold fillings is obnoxious to the patient. A represents the porcelain tips; B, the space to be filled by them; C and D, the opening for retaining-pins; F and G, openings in the base-plates (E) for the pins. Fig. 718 shows the appliance with pins attached.

Figs. 719 and 720 illustrate a case in which the contour of a single incisor tooth was restored in this manner. Fig. 719 shows the palatine aspect of the tooth, in which the openings for two retaining-pins were drilled, the openings being made quite small. In Fig. 720 is seen the porcelain tip attached to the plate and ready for mounting. The two retaining-pins will be observed soldered to the plate. In this case the cervical margin of the natural tooth was made level to afford a secure resting-place for the porcelain tip. The appliance has been in use for several months.

Fig. 719.

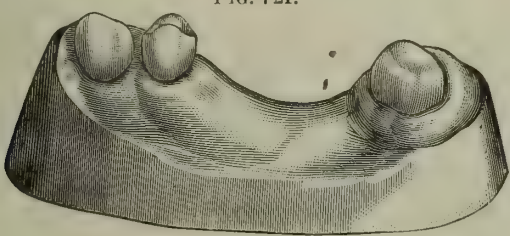
Fig. 720.

Pin-and-Plate Attachments to Cuspids and Bicuspids.

Although chiefly applicable to the incisors, the pin-and-plate attachment may be successfully used on cuspids and bicuspids, or may be combined with crown or bar bridges for molars and bicuspids.

Fig. 721 represents a practical case in which the upper third molar

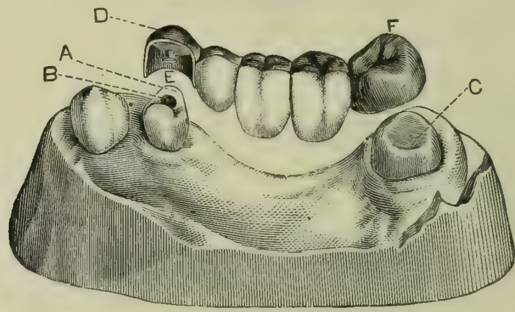
Fig. 721.



and the first bicuspid (both without antagonizing teeth) were utilized for the attachment of a bridge made of gold crowns with porcelain facings, to supply the loss of the intervening teeth.

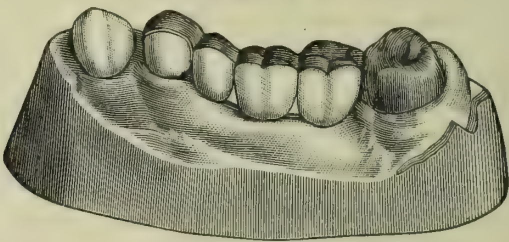
Fig. 722 represents the case as prepared for the bridge: A, the inner cusp of the bicuspid cut down to allow the placing of a sufficiently thick

Fig. 722.



crown-plate; B, a cylindrical undercut opening between the cusps for a retaining-pin; C, the third molar, made uniform in size from neck to grinding surface, the latter also being considerably retrenched; D, the

Fig. 723.



crown-plate of a partial cap made of pure gold, soldered with twenty-carat gold, and so constructed as to cover every portion of the tooth except its buccal surface, the free edge passing up under the gum; E, a retaining-pin adapted to the opening B; F, the gold cap for the molar.

Fig. 724.

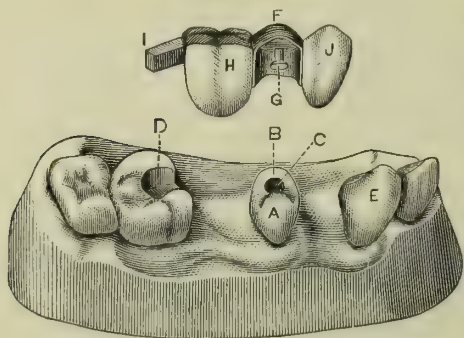


Fig. 723 represents the bridge anchored in position with oxyphosphate cement.

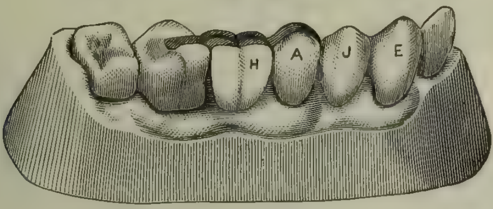
In the above case it will be observed that there is considerable space between the bicuspid and cuspid. This made it readily practicable to give so considerable a thickness to the mesial wall of the partial cap as to hold it securely against the side of the tooth. Had the space been less, contact with the cuspid would have afforded the desired security.

Fig. 724 represents another case in which a bridge was attached by a

bar, partial cap, and retaining-pin. A is an upper second bicuspid (without antagonist); B, its inner cusp cut down; C, opening for retaining-pin; D, second molar, with slot for bar; E, cuspid; F represents the partial cap; G, the retaining-pin; H, a molar crown of gold with porcelain front; I, a platinum bar attached to the crown (H) and made to fit into a slot at D; J, a plain-plate cuspid, heavily backed and strongly soldered to the partial cap, but left without attachment to or contact with the cuspid.

Fig. 725 shows the bridge anchored in position.

FIG. 725.



This case, after two years of wear, is still in perfect condition and doing good service. As it was possible to keep the gold attachments, backings, etc. out of sight, the appearance presented is very natural.

The bridge shown in Fig. 723 has been in use but a few months.

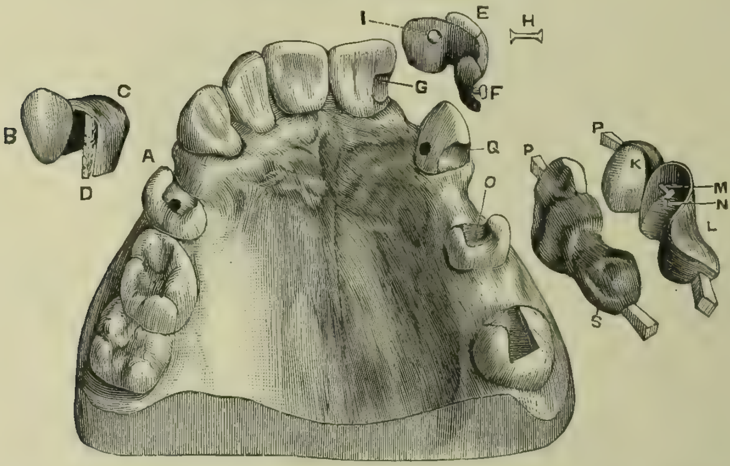
The absence of antagonizing teeth for the bicuspids in each of these cases was a favorable condition, as a considerable thickness could be given to the crown-plate without any interference with occlusion. When the conditions are not so favorable, cutting down the inner cusp to the required extent, and sinking the opening for the retaining-pin to the necessary depth, are processes certainly to be, as a rule, preferred to the entire removal of the crown for the purpose of ferruling the root for the mounting of a crown of gold and porcelain—a procedure, however, not by any means to be indiscriminately denounced, for in many cases it is in the highest degree advisable.

Fig. 726 represents another practical case, in which four interspaces were filled by three separate bridge-pieces. At A is seen a pulpless second bicuspid tooth with a large proximal carious cavity. The left first bicuspid is missing, and was supplied by the porcelain cuspid B attached to the partial cap C, and with oxyphosphate cement anchored in position by means of the barbed retaining-pin D, which is long enough to pass up into the pulp-canal of the tooth.

At letter E is seen a porcelain lateral incisor fitted into position between the right cuspid and front incisor tooth, and attached to the cuspid by means of the retaining-pin F fitted into the opening seen in the palatine surface of the cuspid tooth, and also attached to the front incisor by means of a double-headed platinum pin (H), one head being adapted accurately to the carious cavity seen (at G) on the proximal surface of the front incisor, and the other to the countersunk opening I shown in the incisor plate. The carious cavity was utilized to avoid the necessity for drilling a hole in the palatine surface of the incisor, the teeth being very sensitive. In cementing in position with oxy-

phosphate the cuspid tooth and retaining-pin were treated in the manner already directed, the carious cavity in the incisor being at the same time filled with perfectly plastic oxyphosphate, into which, through the opening I, the double-headed pin H was forced, one head then resting in the carious cavity G and the other in the opening I.

Fig. 726.



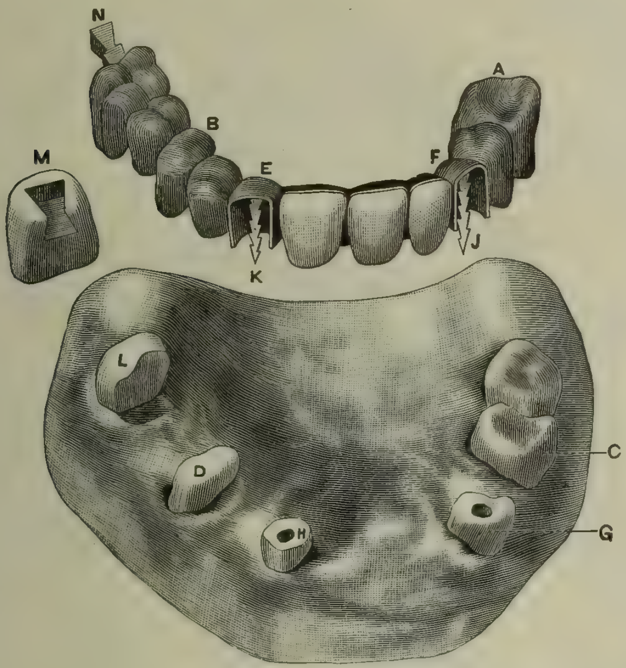
The reason for the employment of the double-headed pin in this case was the fact that the position of the openings in the incisor and cuspid respectively was such that the retaining-pins when adjusted and cemented to the plates were necessarily placed at such angles as locked the appliance in position, and made impossible its withdrawal for soldering without a deflection of either one or the other of the pins. The use of the double-headed pin for one side obviated this difficulty.

At K is seen a porcelain cuspid used as a facing, and at L a molar made entirely of gold, the "bite" being short. These were designed respectively for the spaces between the cuspid and bicuspid and the molar and bicuspid seen on the model. In this case the attachment was by means of the bar seen in the cut cemented into the slot in the molar, and by a partial cap for the bicuspid, the cap being held by two platinum retaining-pins M and N (one passing through the crown, the other through the proximal surface of the cap), soldered at right angles and fitting into the carious cavity O, seen in the bicuspid; in which cavity were placed retaining-grooves for the cement. As a further means of support a bar, seen at P, was soldered to the gold backing of the bridge-tooth K, which bar was adjusted to and rested firmly in the carious cavity seen in the cuspid at Q. At S the completed section is shown in reverse, ready for anchorage. The partial cap was cemented to the bicuspid with oxyphosphate, which material was also employed to secure the bar (P) in the cuspid cavity (Q), a portion of the cement around the bar being subsequently cut out and replaced with gold-foil, as described on p. 858.

Fig. 727 illustrates a case in which gold caps, A and B, were respect-

ively fitted over a very defective molar C and the bicuspid D, while the partial caps E and F were adjusted respectively to the cuspid G and the lateral incisor H, both devitalized, the partial caps being held in posi-

Fig. 727.



tion by the long barbed retaining-pins J and K, both caps and pins being cemented with oxyphosphate. At L is seen the remains of a molar tooth, to which was adjusted a slotted gold cap M for the support of the anchorage-bar N, the slotted cap being anchored to the tooth by means of oxyphosphate cement, and the bar resting in it where the bridge was introduced. This plan of simplifying the attachment of bridges has already been described. (See pp. 864, 865.)

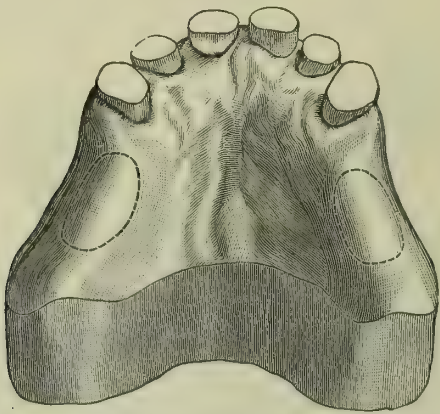
The incisors seen in the cut are of porcelain heavily backed with gold, while molar and bicuspid bridge-teeth, and also the left cuspid, were made of solid gold, the patient preferring strength to appearances.

Bridge-Work with Partial Alveolar Support.

It frequently happens that owing to the loss of the distal teeth the usual anchorages are not available, and the alveolar ridge must be depended upon for support of the bridge-ends. Fig. 728 may be used to illustrate the method in question. It represents the model of a case in which only the cuspid and incisor roots remain in position. Fig. 729 shows the bridge in which caps have been adjusted to the cuspids and front incisors only, the lateral incisor interspaces being filled in with

teeth of proper size and shape, which were soldered in position without attachment to the roots, the use of four instead of six caps greatly simplifying the adjustment of the case.[1]

FIG. 728.



To obtain alveolar support for the ends of the dental bridge, saddles of gold were swaged to contour at the points represented by the dotted lines on the model, the molar teeth resting upon and being attached to these saddles, while suitably prepared bicuspid bridge-teeth served as the connecting-links between the molars and cuspids upon either side. Fig. 730 shows the completed bridge in position.

FIG. 729.

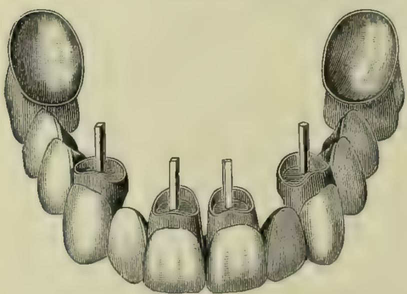


FIG. 730.

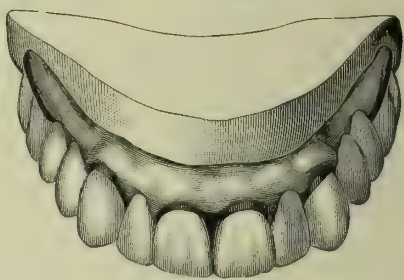


Fig. 731 shows the model, and Fig. 732 the bridge, for another case of this type. Dr. Williams credits the plan to Dr. H. A. Parr of New York.[2] Fig. 733 shows the bridge in position.

The writer has had no experience with this device, and is of the

[1] Provided they be strong and healthy, the plan advocated by some practitioners of extracting such roots as are not utilized for anchorages in the construction of a dental bridge is, in the writer's opinion, objectionable, as in the event of the failure of other anchorage-teeth or roots (always among the possibilities) they might become of the highest possible value as substitutes. The wiser plan is to treat and fill them thoroughly, and allow the artificial crown to rest upon, without being attached to, them.

[2] See *Dental Cosmos*, December, 1885, p. 711.

opinion that, while it may prove serviceable for a time, permanently satisfactory results are not likely to follow its employment. The inevitable accumulation of food under the saddle must always be an objectionable feature, while the rapid absorption which always attends pressure upon the alveolar ridge cannot fail in a comparatively short time to leave the bridge-ends without adequate support. To remedy this difficulty Dr. Williams suggests that the saddle "be not soldered to the bridge, but attached by means of adjustable screws." This, however, will not remedy the chief fault of the saddles figured in the models—namely, the circumscribed surface which they cover, pressure through them being confined to a limited space, instead of being distributed over quite a wide area of the dental arch or ridge, or both, as in the wearing of the ordinary artificial plate.

Fig. 731.

In either of the cases figured in the models some form of base-plate

Fig. 732.

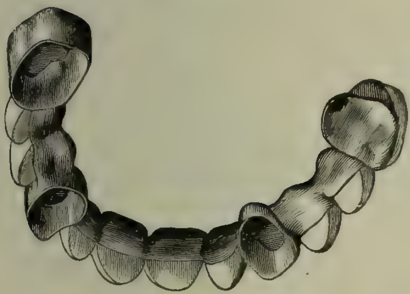
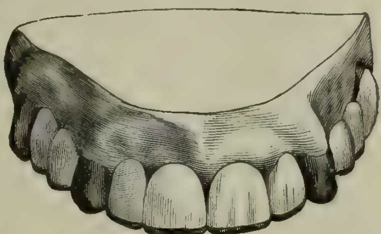


Fig. 733.



covering much more of the ridge than do the saddles would be desirable; and in any given case it is rarely impracticable to devise means by which such a base-plate, with the teeth it supports, can be attached to and gain support from the bridge, and yet be readily removable and replaceable by the patient.

Double-Bar Bridges.

The use of bridges supported at each end or upon each side by a bar is chiefly confined to the anterior teeth, although it is, under favoring conditions, applicable to bicuspids and molars. For the incisors the case represented in Fig. 734 may be taken as typical. The right lateral incisor is missing, and carious cavities in the distal and mesial sur-

faces of the incisor and cuspid respectively favor the placing in each of the end of an anchorage-bar.

Fig. 735 represents a lateral incisor tooth of porcelain properly backed, and with the bar attached ready for anchoring in position. The bar ends should always be square to prevent rotation, and each should be made slightly smaller at the point of junction with the porcelain bridge-tooth than at the free extremity, which rests in the natural tooth, this keystone form making more secure the position of the bar in the tooth when anchored either by cements or by foil.

FIG. 734.

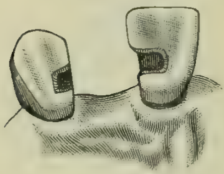


FIG. 735.

To facilitate the adjustment and introduction of the double-bar bridge, it is necessary to cut away the palatine wall of at least one of the carious cavities, as seen in the incisor of Fig. 734.

The bar should be made of platinum alloyed with iridium, and should be made as heavy as the size of the cavities and the nature of the occlusion will permit. Bars less than No. 14 standard gauge would hardly be sufficiently substantial to resist the ordinary wear and tear of the average case.

The making of this form of bridge hardly requires detailed description. A single piece of platinum-iridium wire, not less than No. 14 in thickness, shaped as directed and made long enough to bridge across from cavity to cavity, is placed in position. The farther toward the pulp-chamber of each tooth the respective ends of the bar can be carried the more secure will be its position. From a very shallow cavity the bar is very likely to become displaced in wear. The cavities should be so shaped as to give firm resting-places for the bar ends, and must be made large enough to permit of the packing of foil around them.

The bar being shaped and adjusted, a plain-plate porcelain tooth of suitable size, shape, and shade is fitted into the interspaces and against the labial surfaces of the bar, enough of this surface being cut away to allow the tooth to be brought into alignment. The tooth is then backed with thin platinum and readjusted, and then cemented to the bar, after which both bar and tooth are carefully withdrawn from the mouth, invested and soldered with gold not less than twenty carat fine. In soldering enough gold can be flowed over the backing and the palatine surface of the bar to give them the required thickness and contour. After polishing, the appliance is ready for attachment to the anchorage-teeth.

In such cases the ordinary cements are not usually reliable, gutta-percha being too pliable, and the zinc cements failing either through abrasion or chemical disintegration, while the discoloration resulting from the employment of amalgam interdicts its use in the anterior teeth. Gold-foil, therefore, is usually employed, and gives the best results.

Unfortunately, to securely fill with this material the space between the bar ends and the walls of the cavities is often a work of no small diffi-

culty. It is always well to place in the floor of each cavity a well-compacted layer of gold before the bars are introduced. This makes a firm foundation upon which they can rest, brings metallic surfaces in contact with metallic surfaces, and protects the floor of each cavity against leakage. The two metallic surfaces should be in close adaptation, the one with the other, and to tightly seal the joint a cylinder of soft gold-foil should be placed and pressed between them. This being done, soft gold-foil must with suitable instruments be packed around all sides of the bars until the space between them and the walls of the cavities in which they are severally placed is securely closed.

When the cavities are large and free access to the bars upon all sides can be had, a better plan is to anchor the bars with a strong oxyphosphate cement—cut out the superficial portion, thus making around the bars a groove into which the gold-foil can be securely packed, the cement being thus sealed up and protected from chemical abrasion.

Prof. Hodgkin has devised an appliance in which the tooth is detachable from the bar, this, in addition to other advantages, greatly facilitating the packing of gold in securing the anchorages. Prof. Hodgkin's illustrations and a part of his description are here reproduced:[1]

"Some years ago the following case presented itself, and is a type of a class of cases in which the method about to be described may be attempted with reasonable hope of success:

"The left central incisor had been lost from a blow. The right central had a cavity of some size on its antero-proximal surface, the left lateral a still larger cavity involving the pulp. Fig. 736 represents the gap to be filled, with cavities prepared. The following device was

Fig. 736.

Fig. 737.

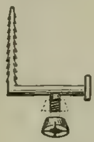


Fig. 738.

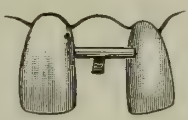


Fig. 739.

Fig. 740.

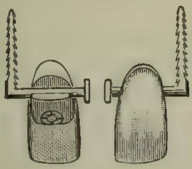
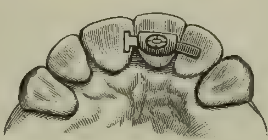


Fig. 741.



constructed: A bar made of wire of the well-known platinum-and-iridium alloy, about No. 14 or 15 American gauge-plate, was bent at right angles; one arm tapered so as to occupy in part the pulp-canal of the lateral incisor. To the other end of the bar was soldered a small flat piece of the same alloy, forming a T. From its centre, and on the side opposite to the tapered arm, was soldered a piece of the same wire. The soldering was all done with pure gold. This downward-projecting

[1] From *Dental Cosmos*, April, 1866.

piece had on it a screw-thread cut before it was attached to the cross-bar. Fig. 737 gives a good idea of the piece thus far. A small conical nut is fitted to this screw.

"The appliance, thus far constructed, was loosely placed in position in the cavities which had been prepared for it, the screw pointing slightly backward to clear the porcelain tooth to be placed upon it. Fig. 738 represents the bar in position in the teeth. The end entering the central incisor was made T-shaped for greater security of anchorage. A small piece of platinum plate, quite thin, was cut to the proper shape; a hole punched in it sufficiently large to allow the screw to pass, and this was adjusted to the bar with a burnisher, fitting the bar somewhat like a saddle, its anterior and posterior borders being of shape and length indicated by the case, the width governed by the space to be filled.

"A plain-plate cross-pin tooth was selected and ground, care being taken to cut away the back of the tooth above the pins, so as to have plenty of room for the screw, which was determined by trial. The tooth was backed with thin platinum, and it and the saddle cemented with adhesive wax, and carefully tried on to see that the little saddle exactly fitted the bar. The whole was now removed, invested, and soldered. The punched hole in the saddle indicated the position of the hole to be drilled, which was given the same pitch backward as the screw. Fig. 739 illustrates the tooth and backing after soldering. The hole for the screw was countersunk from without to receive the nut which was made to fit it. This device of screw-and-nut pivoting is the design of Dr. Bonwill, and may be found fully illustrated on p. 416, vol. xxii., *Dental Cosmos*, of which invention the one under consideration is an outgrowth. The iridium alloy is better than gold for nut and screw, as it is tougher and holds the thread better. The nut has a crucial slot, and a suitable forked screw-driver can be made from a broken excavator. The countersink in the backing should be a little deeper than the size of the nut, and recess filled after screwing up with zinc phosphate, which serves the double purpose of giving a smooth-contoured surface and of steadying the nut in case of strain. If gold is preferred for the bar it may be used, or the appliance may be electro-plated.

"The appliance, put together, or 'assembled,' as the machinists say, is seen at Fig. 740, and placed in position in Fig. 741.

"For the insertion of such a fixture, the rubber dam being adjusted, the cavities and root having been previously prepared, the bar and tooth are placed in position. Any of the cements may be used. Zinc phosphate is perhaps preferable, and the whole affair cemented in as if for permanent retention. The softness of the moderately slow-setting plastic cement gives time for perfect and accurate adjustment. When fully set the surplus cement is cut away, one side at a time, for the gold filling, the porcelain tooth meantime being removed by unscrewing the nut. This gives a freedom of access to the bar and to the cavities which allows easy manipulation of the gold, which may be solidly built around the cemented ends and into the anchorages, contouring to ideal. This operation completed, the rubber dam may

be removed and the tooth tried on again, the articulation having been previously attended to. It is now screwed home to place. Slight alterations in the 'pitch' may be made by cutting away the countersink front or back, though ordinarily this is not necessary. The groove in which rests the bar is usually tight enough for practical uses, but if a fluid-tight joint is desired, it may be made with a thin layer of gutta-percha placed in the groove, the tooth warmed and screwed tight, and the surplus trimmed off after cooling. If gutta-percha is used, it will necessitate a tightening of the screw the day after, as this material will slowly spread.

"The work thus completed is strong, firmly anchored, admits of easy removal of the tooth in case of accident to the porcelain, and even repair of the fillings should not be beyond the skill of the well-trained dentist.

"Four years' use of some of these appliances seems to justify the prediction of fair durability. In any and all cases the occlusion should be so slight as to spare the supplied tooth, as prudence suggests that no appliance should be put to undue strain; and this is more true of front than back teeth, as leverage is more dangerous than vertical pressure."

Another method for securing the porcelain tooth to the bar in this class of cases is that devised by Dr. J. F. Wardwell of New York. "His plan consists in so arranging and soldering a thick narrow gold plate to the platinum pins in the porcelain crown, and so bevelling the sides of the plate toward it, as to have this plate slide tightly into another gold plate shaped to receive it (Fig. 742, A, B). This second

Fig. 742.

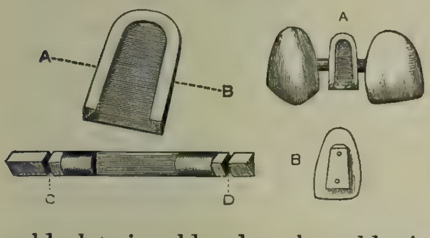


Fig. 743.

gold plate is soldered to the gold wire, which is built into cavities (Fig. 743, C) in the adjoining teeth with gold-foil, and by enclosing the bevelled sides of the plate on the porcelain 'dovetails,' it holds the crown in position. The crown is then pressed into place, and made secure by filling in gold-foil near the cutting edge of the tooth after the wire with the plate soldered to it is pressed into place."[1]

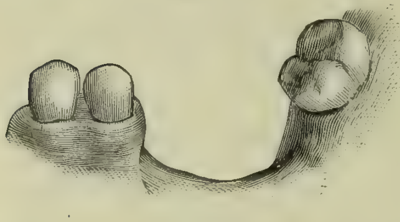
Removable Bridge-Dentures.

When for any reason it may be deemed undesirable to attach bridge-dentures to their anchorages, they can often be made detachable by the patient. In Fig. 744 is represented a case in which this plan was adopted. The first and second lower molars of the left side are miss-

[1] *Notes in Operative Dentistry* (p. 139), Webb.

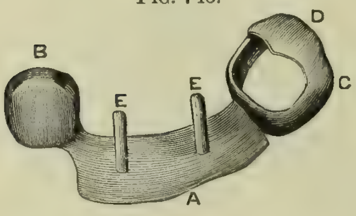
ing; the third molar is tilted forward to a marked extent. The second bicuspid tooth has no natural antagonizer, while the occluding upper molar touches the coronal surface of the lower molar only at or near its mesial edge. Hence the distal portion of the crown can be covered with a crown-plate without interference with the normal antagonism. To secure for the denture support from this tooth, a very heavy ring of half-round gold-and-platinum clasp alloy was fitted around the tooth; to this was soldered a crown-plate made of the same alloy (No. 24 standard gauge in thickness), which crown-plate covered only the distal half of the tooth.

FIG. 744.



Around the bicuspid was fitted a cap of twenty-two-carat gold, the coronal surface of the tooth being first cut down to the necessary extent, and a sufficiently wide separation being made between it and the adjoining bicuspid. To the interspace was then fitted a base-plate made of two thicknesses (each No. 24 standard gauge) of platinized gold joined by solder. This base-plate was made to extend well around the bicuspid cap, and also the ring made for the molar, so that there might be broad surfaces of attachment between them. The base-plate ring and cap being made, they were adjusted to place in the mouth, and a matrix of plaster moulded around them; in which matrix, after withdrawal from the mouth, the several parts were replaced, cemented, invested, and soldered. In Fig. 745 is seen the base-plate with its attachments: A, the base-plate; B, the bicuspid cap; C, the ring for the molar, with the crown-plate D soldered to it; the pins E, E were soldered to the plate to serve as attachments for a porcelain block of two teeth carved for the case and made with suitable holes for the pins, these holes being countersunk at their coronal ends. To make a tight joint, hard rubber was packed between the block and plate, and also in the pinholes, and the case vulcanized. Either single or sectional rubber teeth of the ordinary pattern and attached in the ordinary way might have been employed, but the result would not have been so artistic.

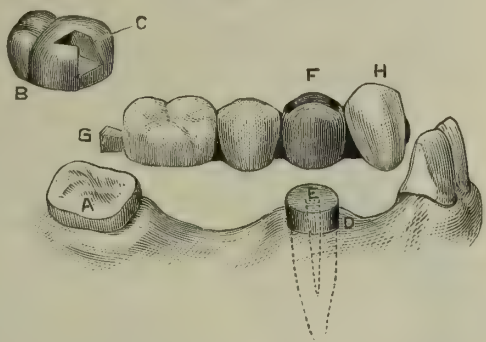
FIG. 745.



This case has been in use since 1880, and does perfect service in mastication. This form of denture should be worn only at meal-time. If kept constantly in the mouth, erosion of the enamel, and ultimately decay of the dentine, are quite certain to follow. No such effect will be produced, however, if after each meal the denture is removed, carefully cleansed, and replaced only at the next meal-time. The necessity for an observance of this rule interdicts the employment of this form of denture in cases where for the sake of appearance it must be constantly worn.

Under such conditions detachable bridge-dentures may be made by employing a slotted metallic cap for the support of an anchorage-bar, or by cementing on the anchorage-roots caps somewhat shorter than was the natural tooth, such caps having sides as nearly straight as possible, other caps being then made and telescoped over these, the roots being thus thoroughly protected, and only metallic surfaces being brought in contact between the caps. Fig. 746 represents a case in which both these devices have been employed. Over the second molar lower root A was fitted and cemented a molar cap B containing the slot C. Over the second bicuspid root D was placed the cap E, which for greater security was fitted with a retaining-pin passing into the pulp-canal. Over this was made a closely-fitting anchorage-cap (F), the crown-plate of which was made to rest firmly upon the root-cap. In the space between the molar and bicuspid roots were placed a molar and bicuspid tooth made entirely of gold, the bite being very short. These were joined to the anchorage-cap F and to the anchorage-bar G, which latter was closely fitted to the slot C. The porcelain cuspid tooth H, heavily backed, was soldered to the mesial surface of the anchorage-cap F, from which alone it received support. This denture can be cemented in position, or can be left uncemented and removable, at the pleasure of the patient.

Fig. 746.



As such removals and replacements, however infrequent, are always attended by some wear, this, together with the strain upon the outer cap, which is inevitable in mastication, is certain sooner or later to make the joint between the caps a loose one, however tightly they may have been telescoped at first. For this reason removable dentures of this form are better adapted for use in the lower than in the upper jaw, as in the lower jaw gravity favors its retention.

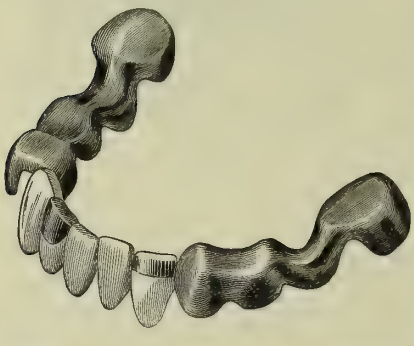
In the *Dental Cosmos* for July, 1883, Dr. Dexter describes a removable bridge-denture which he designates as a "cap-plate." The following is Dr. Dexter's description of the appliance:

"Take a case where, on the lower jaw, there are standing in the mouth a third molar, a canine, and first bicuspid on each side—six teeth in all. These teeth are shortened by breakage and mastication, so that the upper incisors close to within an eighth of an inch of the gum-line between the canines; added to this, they are so tipped and twisted in their places as to make it very difficult to properly adapt an ordinary denture to the spaces between them; and lastly, let the patient evince entire abhorrence of, and a fixed resolution not to permit, the resting or pressure of any appliance upon his gum-tissue. Such a case is the one for which I have constructed this cap-plate. Such cases are often treated

by building up or down the natural teeth with gold in order to open the bite, and then replacing lost teeth with an ordinary plate. My apparatus, however, accomplishes both these desiderata in one operation, while simultaneously avoiding any and all pressure upon or irritation of the gum.

"The appliance shown in Fig. 747 is constructed as follows: Caps of gold-and-platinum alloy, of about 26 to 28 United States standard gauge, are struck up to fit over and down the sides of the natural teeth selected for the piers, fitting closely. If all the supporting teeth stand perpendicularly and parallel with each other, thus creating no 'undercut' (so to say), the sides of the caps may encircle the teeth as far as possible (*not*, however, impinging upon the gum-line), and be simply slit (in two or more places on each tooth) perpendicularly, so as to spring apart and allow of sliding the whole over the natural convexities of the teeth, the sides coming together again when in place and thus holding the whole apparatus firmly. But should the teeth be tipped or leaning and not parallel, the sides of the caps must then extend over only such parts as can be closely fitted and yet be sufficiently perpendicular and parallel to allow of removal and replacing of the appliance. Of such a character is the case now shown you, there being only one place on the six caps where a *slit* is of value; the sides of the caps being so fitted as to hold partly by their own elasticity and partly by that of the whole apparatus. Such a case, of course, will most severely try the capabilities of any artificial denture; and not the least merit of the present piece is its triumph over, and perfect and *practical* adaptation to, the obstacles of an exceptionally difficult case.

Fig. 747.



"The caps, when struck up, will not cling to the teeth when in place; nor should they, for they must be capable of easy removal during succeeding processes. But when the piece is ready for final insertion the sides of the caps must be *sprung inward* sufficiently to hold to their supports with firmness.

"The caps being now made, it is in order to determine the length of 'bite' needed. Place the caps in position in the mouth, and build wax on their grinding surfaces to a proper length and contour, both side and grinding. Invest, remove wax, and flow into its place eighteen-carat gold. Shape the grinding surfaces, by trial in an articulator or the mouth, to the proper occlusion. Next take an impression with the caps in place, pour the model, select and back plain-plate teeth, and wax them in place. Invest the whole, remove the wax from the backs of the teeth, and fit in the spaces between the caps bands or bars of irido-platinum alloy (or gold, as circumstances may determine), being careful that the bars fit *accurately* to the *backings* of the porcelain teeth and to

the *caps* at each end. In fitting the bars to the caps select such points of attachment as will not interfere with the *spring* of the slit sides of the caps. If necessary, let the bars avoid the *sides* of the caps, and reach by curving to the *tops* or grinding surfaces. Should you desire to arrange the porcelain teeth irregularly, you need not hesitate to do so. Set them just as you would for rubber or celluloid, and then, simply taking a 'finger impression' of their backs with modelling composition or wax when invested as above stated, and making dies, you can readily 'strike up' your bars to fit the irregular positions of the backings. But should this be difficult on account of great irregularity or stiffness of bars, then construct the bars of two or three thicknesses of metal, each struck up separately and then 'sweated' into one. Next solder the bars to the backed teeth, but *not* to the caps as yet. The reason is that *perfect* adaptation of the bars to the caps is absolutely necessary to the success of the piece. Therefore, now place the caps in place in the mouth, and wax the bars with their attached teeth in the spaces between them, filing, grinding, and adjusting until all is exactly as required. Then (and not until then) take an impression of the whole in place, the apparatus coming away with the plaster. Pour the impression with plaster and pumice, sand, or asbestos (sand is best); carefully remove the impression-plaster, invest outside the model with its sustained apparatus, and then solder the caps and bars together. In doing this as little solder as possible should be used, to prevent warping of the whole.

"The bars should have a broad, firm hold on the caps, but the contour of their union should be made on the bars *before* they are united to the caps, and *not* by flowing on a body of gold while uniting the bars and caps sufficient to attain the desired hold and shape of union. On the contrary, the bars should be properly shaped at their ends, and carefully fitted to the surfaces to which they will be attached, when a small amount of solder flowed into the joint will make a perfect union and give all the strength possible. This is *not* plumbing work. All that now remains to do is to spring or bend slightly inward, as before directed, the sides of the caps, so that they may grasp their supporting teeth firmly, yet not too much so to create difficulty in removal or insertion; then finish and polish. Burnishing is generally objectionable, since it gives, in some lights, a *black shine* to the piece, adding greatly to the prominence of the appliance as a part of the view whenever the wearer opens his mouth. . . . .

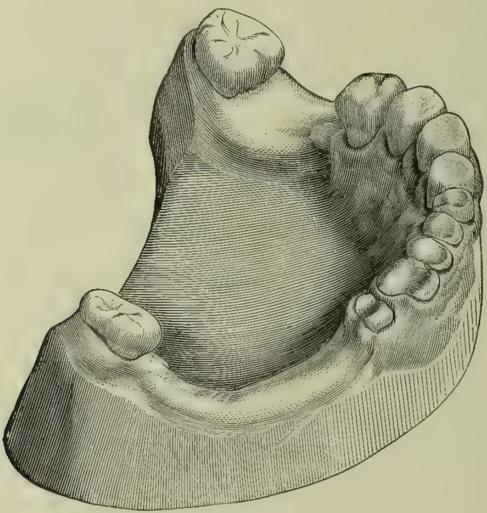
"In the piece shown there are six caps, three on a side. There are five incisor teeth placed between the canines, two of which are capped with gold to break up the uniformity of porcelain in front as contrasted with the uniformity of gold behind, and thus help to evade artificiality of appearance. Between the molar caps and the double caps for canine and bicuspid the connecting-bar is horizontally placed, dipping downward to parallel the gum-line, as well as to evade an encroaching molar above. When necessary, an artificial tooth or teeth can be ground and soldered to these bars. Generally, however, the connecting-bars should be perpendicularly placed, to ensure resisting strength in the line of the attacking force."

Dr. R. Walter Starr gives in the *Dental Cosmos* for January, 1886, the following description of a removable bridge-denture:

"The case of Mr. W—— presented difficulties of an unusual character, as may be seen by inspecting, Fig. 748, which renders detailed description unnecessary.

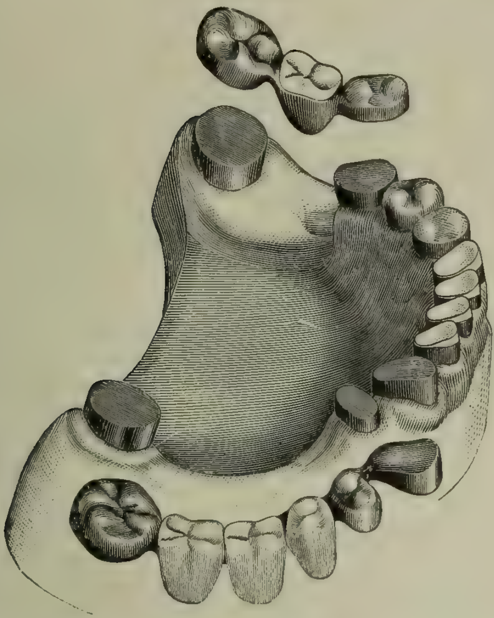
"It will be observed that the molars and the left second bicuspid overhang to a degree that would make the taking of an accurate impression by ordinary methods wellnigh impossible. After a careful study of the case it was decided that two separate pieces of removable bridge-work should be attempted, and, as an essential preliminary step, the overhanging sides of the molars and bicuspids were ground with engine corundum wheels and points until those sides were made much

Fig. 748.



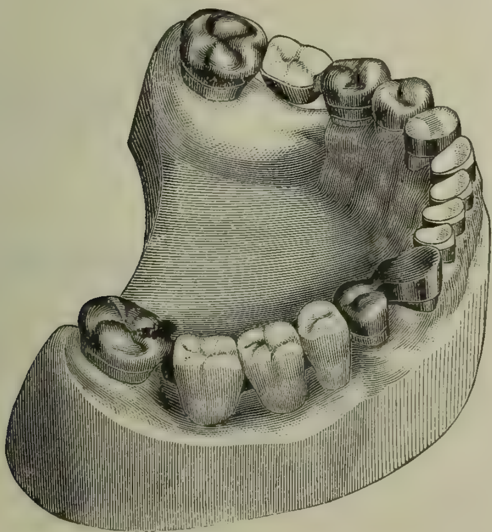
less inclined, when plaster impressions were taken, first of one half, and then of the other half, of the jaw. Gold cap-crowns were closely fitted over the molars, left second bicuspid, right first bicuspid, and cuspid stump. Gold crowns were made to telescope over all the caps, which were then, by means of oxyphosphate cement, fixed firmly on the teeth. Suitable plate teeth were selected, fitted, backed, and hard-waxed in place between the telescoping crowns. After hardening the wax with cold water from a tooth-syringe, the pieces were carefully removed, invested, and soldered. The two completed bridges were easily replaced on or removed from the supporting capped teeth, and their appearance when detached is correctly shown by the illustration, Fig. 749, which also shows the capped teeth and stumps. This figure likewise shows the results of the novel method employed in crowning the incisors. Gold collars were fitted tight on the necks of the incisor stumps, and the new-style porcelain caps adjusted in the collars and set in the oxyphosphate cement which had been packed into the collars; thus at the

FIG. 749.



same time fastening the collars on the stumps and the caps in the collars, as shown completed in Figs. 749 and 750.

FIG. 750.



"Fig. 750 illustrates the finished crowns and bridges, which latter were secured in position by placing a small piece of gutta-percha in each

of the telescoping cap-crowns, which were then warmed and carefully pressed in place, the gutta-percha filling only the spaces between the flat tops of the caps of the natural teeth and cusped caps of the bridges.

"Whenever, for repair or for any other purpose, it shall become desirable to remove one of the bridges, that may readily be done by applying a hot instrument or hot air to the caps to soften the gutta-percha sufficiently to permit the telescoping bridge to be taken off.

"A full upper vulcanite denture was made to replace the old one, which by improper occlusion had thrown the full force of mastication on the anterior teeth of the lower jaw, and produced the destructive action that resulted in the deplorable loss of tooth-substance shown in Fig. 748.

"The prosthetic devices thus briefly described have so far proved perfectly satisfactory to both patient and dentist. The obvious difficulties of the case, and the somewhat novel means employed in supplying useful and secure dental substitutes, seem to justify the writer in bringing the case to the attention of the profession."

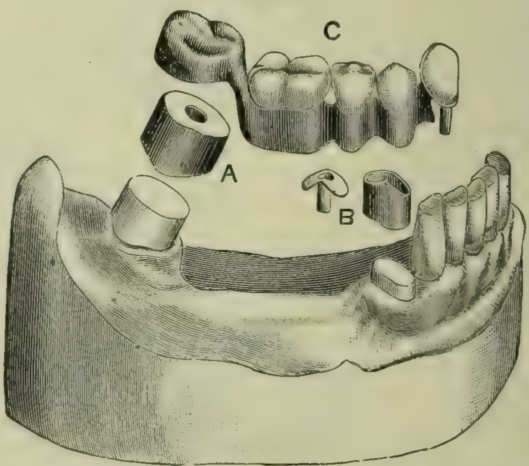
In the *Dental Cosmos* for August, 1886, Dr. Starr thus describes another removable bridge-denture:

"A case presenting unusual difficulties was the recent occasion of an adaptation of the method I described in the April number of the *Dental Cosmos*, to which reference is made for details not essential to this record. The forward overhang of the inferior right second molar was so excessive that an impression could hardly be taken, even piecemeal, until with corundum wheels and points the sides of the tooth had been made parallel, or rather slightly tapering, to form a truncated cone, with the neck

FIG. 751.

FIG. 752.

FIG. 753.



as a base. The molar was alive and sound, but the crown was gone from the pulpless cuspid, which I suitably shaped by means of the peculiar root-trimmers shown by Fig. 751. For shaping superior roots I have designed the pair of straight trimmers shown by Fig. 752.

"An impression was then taken, the cast from which is illustrated by

Fig. 753. A seamless gold collar was, by means of a slightly tapering mandrel, made to exactly fit the tapered natural molar, the lower edge of the collar cut to conform to the gingival margin, a cap-piece of gold plate soldered to the top edge of the collar, and a hole drilled through the centre of the completed cap (A, Fig. 753). Care was taken to so fit and proportion the cap that it would require finally pretty hard driving to send it home on the tooth; but first there was fitted to the cap a telescoping seamless collar, on which was soldered a gold plate, with cusps, to form a molar crown, as shown in Fig. 753. The molar was then thoroughly dried, slightly painted with agate cement, and the cap, A, driven hard down with a flat pine stick held upon it and struck with a mallet, the hole in the cap enabling me to see when the cap was quite down. The cuspid was then likewise fitted with a seamless gold collar, the top edge of which was given a roof-shape, as seen above the root in Fig. 753. A piece of gold received a corresponding roof-shape, had a short section of gold tubing soldered into it, and was trimmed to the outline of the collar, beside which, B, Fig. 753, its form is seen, and to which it was subsequently soldered, after suitable investment to keep the parts in proper place. The root-canal had been previously prepared to receive the tube, which, with its roofed cap, was with stick and mallet driven hard down over the root. A piece of gold wire exactly fitting the tube had a roof-shaped piece of properly-perforated gold plate slipped over it into position on the root; became fixed in such relation by a drop of melted hard wax; was removed, invested, soldered, and finished in such shape that, excepting the hollowness, it looked like the tube and cap B, Fig. 753.

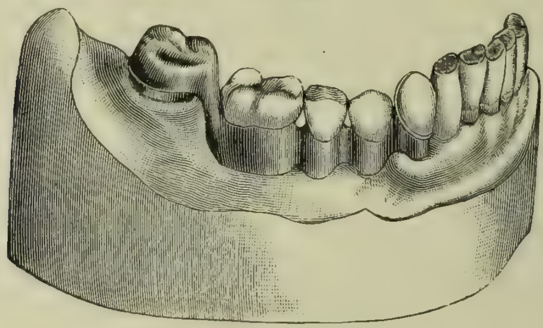
"The relations of the occluding teeth had, of course, been determined by an articulating model, and by means of it a series of seamless gold collars and cusp-crowns were adjusted on a thin platinum plate fitted on the cast between the cuspid and second molar, and the collars soldered to the plate after investment. The truss thus formed received an appropriate finish by the rounding and smoothing of its basal borders. A plain-plate cuspid was backed with gold plate and fitted on the roof-plate, to which, after determining its proper occlusion, it was secured by hard wax; removed, invested, and soldered. It was then put into the tube on the root, the telescoping cap put over the molar, the truss put in position in the mouth, and the whole covered with plaster and sand contained in a suitable sectional impression-cap, which enabled me to hold the mass steadily in place until the mixture was sufficiently hard to bring away cap and truss and roof-plate all in proper position. A second mixture of plaster and sand, and a suitable trimming of the first mixture after all was hard, sufficed for the soldering process that resulted in the denture, which, when finished, appeared as shown detached at C, Fig. 753, and mounted on the cast in Fig. 754. It went firmly to place in the mouth, and yet was removable in the possible event of accident to the denture or for readjustment of the cusp-crowns, which latter could easily be done by warming the piece sufficiently to soften the gutta-percha, replacing the denture on its anchorages, and directing the proper closure of the occluding tooth.

"The ultimate success of this class of work depends wholly upon

the character of the preliminary treatment, the absolute precision of fit and adjustment on the anchorages, and the proper adaptation of the denture to its base and to the occluding teeth.

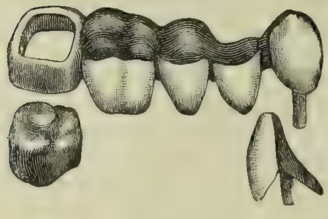
"Dr. C. M. Richmond of New York City, in making removable

FIG. 754.



dentures of the entirely soldered kind, employs a zinc die made from a cast of the anchor tooth with its cap on. He makes of crown metal (platinum faced with gold) a collar somewhat smaller than the tooth-cap, and deep enough to reach from the gum to about a sixteenth of an inch above the cap. He then drives the die into the collar so far that the extra sixteenth of an inch can be hammered over and burnished down on the die-end to form a flanged collar. Outside of this, in the same manner, he forms another flanged collar and then solders the two together, thus obtaining a close-fitting, stiff collar that will not stretch in being telescoped on and off the anchorage, and is kept by the flange from being forced too far over the tooth-cap. A denture of this kind is illustrated in Fig. 755, which also shows his post-and-roof device in another form than that previously described.

FIG. 755.



"It may be well to add that in the use of an impression-cup for holding the plaster and sand around the parts to be subsequently removed from the mouth the *inside* of the cup should first be slightly oiled, to allow a separation of the cup when the mass is being prepared for the soldering."[1]

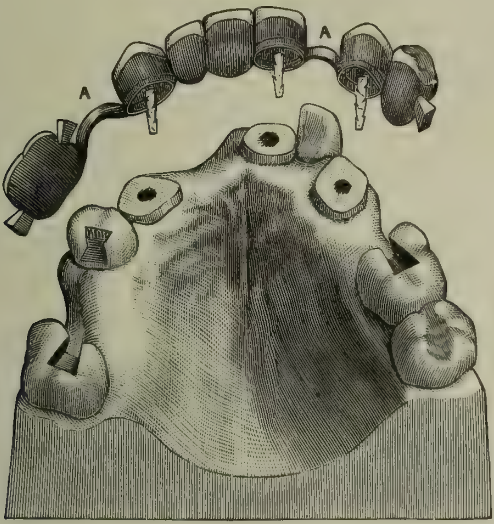
CONNECTING BANDS FOR BRIDGE-PIECES.

Fig. 756 illustrates a case in which it was desirable to preserve intact two natural teeth of good quality, the bicuspid and lateral incisor, and yet introduce a continuous bridge-denture for the purpose of giving the anterior roots the additional support which comes from attachment to molars and bicuspids. This was accomplished by uniting the three sections of the bridge by the connecting bands of gold seen

[1] For other removable bridge-dentures, see pp. 916, 924.

at A, A in the figure. Such bands are best made of platinum-iridium wire ovoid in shape. They should rest lightly upon the gum close to, but not touching, the teeth around which they are placed, so that food lodging between the teeth and bands may be readily washed away or be otherwise removed. In the case in question the bridge rested upon the incisor and cuspid roots, seen in the cut, and derived further support from bars anchored in the slots seen in the molars and bicuspid. The use of the connecting bands secured that arched form of

FIG. 756.



the denture which from the nature of the case, was required to give strength and rigidity, while at the same time their use made unnecessary any mutilation of the natural crowns other than the forming of slots in the molars and the bicuspid, in the latter of which a proximal carious cavity was utilized for the purpose. (For a description of the device under consideration the profession is indebted to Dr. Williams.[1])

OTHER METHODS AND DEVICES IN CROWN- AND BRIDGE-WORK.

Although bridging processes have so recently come into general use in dentistry, so many are engaged in their elaboration that the literature of the subject has grown to quite formidable proportions. As many of the plans proposed have decided value, and as nearly all may prove of service in individual cases, even if they are not found to have universal applicability, it has been deemed advisable to here give a full presentation of such additional methods and devices in crown- and bridge-work as are representative in character.

While, as above stated, the general introduction of bridge-work into dental practice is of comparatively recent date, the plan is not by any means of modern origin, several works on dentistry published in the

[1] See *Dental Cosmos*, December, 1885.

early part of this century containing descriptions and illustrations of devices of that character. Fig. 757 is a reproduction of one of these.

FIG. 757.

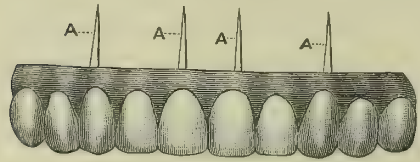
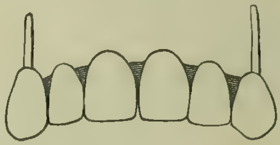


FIG. 758.



It appeared in a work by M. N. Dubois de Chemant, "inventor of mineral paste teeth,"[1] which work was published in London in 1804. The following description accompanies the illustration: "A row of teeth with a part of the gums: A, A, A, A, four pivots by which they may be fastened to stumps remaining in the jaw."

In a work published in Paris in 1805, by J. B. Gariot,[2] four teeth, attached by two pins passing into roots are figured.

A work published in Paris in 1820, by C. F. Delabarre,[3] contains plates in which several bridges appear.

Fig. 758 is taken from the work of F. Maury,[4] first published in 1828 in Paris. It is described as "Six Incorruptible Teeth mounted upon a plate carrying two pivots."

In America, too, bridge-work was not unknown. As early as April, 1855, Dr. William H. Dwinell fully described a method of crown- and bridge-work in a paper on crystalline gold published in the *American Journal of Dental Science* of the above date. In this, after giving methods of forming crowns, artificial cusps, etc., in which many more recently-published devices are distinctly anticipated, he says: "Crowns may be secured to the roots of teeth as prepared above, either by wood or gold pivots, as usually practised: gold pivots are generally preferable. Some, however, prefer another method, as follows: After the root is filled with gold as above described, and properly finished, an impression is taken of its surface in wax, from which castings are made, and from these plates are swaged: these are adjusted to the roots, and a golden pivot is soldered to each of their upper surfaces. A plate tooth is now skilfully adapted to the fixture, when it is ready for use. *In this manner a plate may be extended across an intervening space unoccupied by roots, and an unbroken row of teeth mounted upon it.* It may be urged against this method of inserting teeth that it must cost the patient three or four times as much as it would by the old process. It is sufficient to say, in reply, that the method under consideration is tenfold more valuable."

Coming down to a later period—January 23, 1871—we find "Ben-

[1] *A Dissertation on Artificial Teeth, evincing the Advantages of Teeth made of Mineral Paste over Every Denomination of Animal Substance,* by M. N. Dubois de Chemant, formerly surgeon of Paris, residing now in London—London, 1804.

[2] *Traité des Maladies de la Bouche,* par J. B. Gariot, Chirurgien honoraire de la Chambre et Dentiste de S. M. C. le Roi d'Espagne, Paris, 1805.

[3] *Traité de la Partie mécanique de l'Art du Chirurgien-dentiste,* par C. F. Delabarre, Docteur en Médecine, Chirurgien-dentiste du Roi, Paris, 1820.

[4] *Traité complèt de l'Art du Dentiste d'Après l'État actuel du Connaissances,* par F. Maury, Dentiste de l'École royale-polytechnique, Paris, 1828.

jamin James Bing, Doctor of Dental Surgery," entering the papers necessary to secure in England a patent for an "improved means for securing artificial teeth in the mouth." The following is the "provisional specification:" "The object of the invention is to effect the security and permanent fixture of artificial teeth in the mouth without the necessity of employing plates, clasps, hooks, or pivots. For this purpose the artificial tooth or teeth are connected to those adjoining by a metallic band or bar or metallic bands or bars, the ends of which are passed into holes which may already exist or are drilled for the purpose of receiving them in such adjoining teeth or roots; and these ends are there held by the ramming therein of gold used in 'stopping' teeth, or other suitable cement. In some cases the artificial teeth may be connected to these metallic bands or bars by riveting, clipping, or otherwise, or the bands or bars may be passed through or over portions of the artificial teeth. By these means are obtained security and strength and other advantages."

The drawings illustrating the invention are, together with the descriptive text, here reproduced:

Fig. 759.

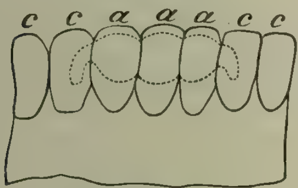


Fig. 760.

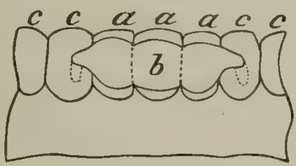


Fig. 761.

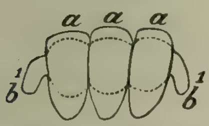
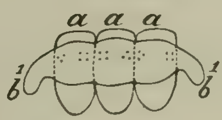


Fig. 762.



Description of Drawings.—"Fig. 759 shows a front view and Fig. 760 a back view of three artificial teeth, *a*, *a*, *a*, connected to a band of metal *b* (but the number may be varied) for the purpose of being connected to other teeth in the mouth. The band *b* is connected to the teeth *a* by rivets and cement, or otherwise as may be found most convenient; but in order to carry out my invention the band *b* is provided with projecting horns b^1, which are shown turned downward, so as to pass downward into holes which may already exist or which may be formed for them in the adjoining natural teeth or parts thereof; and when these ends have been thus passed into such holes, they may be held securely there by the ramming in with them of gold such as used by dentists for stopping teeth, or by the aid of other suitable cement.

"Fig. 761 shows an external view of teeth thus applied, and Fig. 762 shows a view of the same from the inside of the mouth; *c*, *c* represent the natural teeth. In place of the ends b^1 being turned downward or toward the gums, they may be turned and passed into adjoining teeth in other directions."

In the *Dental Cosmos* for December, 1879, the late Dr. Marshall H. Webb published a description of a case of bridge-work which he elsewhere states is "executed somewhat according to Dr. Bing's plan." Dr. Webb's description and illustration are here reproduced:

"The insertion of a crown without plate or clasps where no root remains is a difficult operation, but when well performed and the crown attached to teeth that are firm in their sockets, it is both satisfactory and permanent.

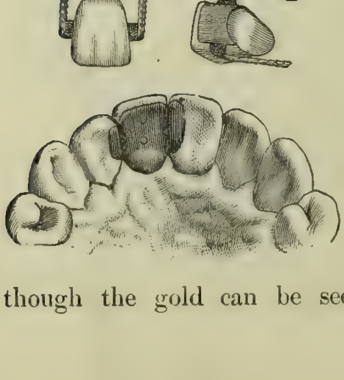
"The first such operation performed by the writer was completed February 12, 1873, and the crown now remains as firm as when in-

serted. The operation was performed in the following manner: After suitably forming the cavities in the proximate wall of each tooth next the space left by the loss of the one that had been extracted (unnecessarily) some years before, an impression of the parts was taken, and a plain porcelain crown was selected, fitted to place, and backed with gold plate (eighteen-carat). A portion of the backing extended about one and a half lines from each side of the crown for insertion in the cavities prepared in the adjoining teeth, and to these parts a gold wire was soldered to fit into the pulp-chamber of the central and lateral incisors. A small gold plate was then formed to fit upon the gum, covering as much space as was taken up by the neck of the natural tooth. When the backing was riveted to the pins in the porcelain, and this placed in position, and while the whole rested on the small plate upon the gum, the backing and plate were so secured by wax that they could be removed intact, and, after being placed in a matrix, soldered. Each extended side of the backing and the surface of the wire were barbed with an engraver's lossing-tool, so that the gold-foil would the better secure the crown when filled into every part.

"The porcelain, with the gold attachments, being ready for insertion, a piece of light medium rubber dam was put in place on two teeth each side of the space to be filled and over the gum upon which the crown was to rest. (The rubber takes up but little space, and this is more than compensated for when the ligature—waxed floss silk—is pressed to or near the neck of each adjoining tooth.) Oxychloride of zinc was then placed in the pulp-chamber of the central and lateral incisors, and the crown at once pressed to place. When the cement had hardened sufficiently to safely admit of further progress in the work, a portion of it was cut away from around the wire so as to make proper anchorage for the gold. Small pieces of light cohesive gold-foil were then impacted around part of the wire and that portion of the plate extending into the cavities, and the crown was thus secured. The porcelain and gold attachments as prepared for insertion and the crown in position are here illustrated (Fig. 763).

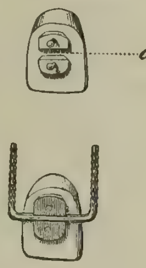
"The cavity in the central incisor was extended to the cutting edge of the tooth, that access might be had to the wire and both sides of the plate: foil could not otherwise have been put in place, unless a portion of the labial margin of enamel were cut away, and this would have been objectionable because of the exposure of gold. A small part of the labial instead of the cutting edge of the enamel of the lateral was removed, for the reason that there is not such a body of tissue as to safely allow it to be cut away to the same extent as in a central incisor. The margin of enamel was so formed and the foil so inserted and finished, however, that though the gold can be seen, it is not conspicuous.

FIG. 763.



"While the operation just described has thus far proved successful, yet there is a possibility of the porcelain being broken from the platinum pins which hold it to the gold plate. To avoid such an accident a groove should be cut in each side and along the cutting edge of the porcelain, that gold-foil may be impacted into it after a heavy backing of gold plate and the wire have been fixed in place and soldered. After the groove has been cut in the porcelain with a fine-edged corundum disk, one with an edge of the diameter of the gold wire selected for the case should be used to make a groove across the porcelain between the pins (Fig. 764, *a*), into which the wire to connect the artificial crown with the natural teeth is to be placed (Fig. 764), either beneath the plate or so that the edges of the latter may be joined to it, as the necessities of the case may require.

Fig. 764.



"A starting-point should be made either between the gold backing and porcelain or between this and the wire, and the latter firmly fixed in a hand-vise while the gold-foil is being impacted with the electro-magnetic mallet. When the gold is properly and solidly placed in the groove and over the backing and wire, it not only aids in securing the porcelain, but the contour of the crown can be nicely filled out and the operation made durable and beautiful (Fig. 765).

Fig. 765.

"The surface of the gold placed along the base of the crown to the edge of the porcelain, and which is to rest against the gum, together with the palatal portion, ought to be properly formed and finished before the crown is put in place; and this should be done in the manner before described. There should be a little space between the wire and cervical wall in each tooth to which the crown is to be attached, and narrow pieces of light gold-foil carefully placed in this part, between the wire and enamel, with small curved instruments and with the aid of the mallet: the surface of the gold at this part at least should be smoothly finished with very narrow ($\frac{1}{16}$ in.) strips of fine emery-cloth before the rubber dam is removed.

"In cases where the pulp is living in one or both of the teeth to which an artificial crown is to be attached, the heavy gold plate or the wire must be so arranged as to fit as accurately and to be made as secure as possible in the cavities prepared for them. In some cases, and where the form of the cavity admits of it, it is better to adjust and solder a small gold plate to the end of, and at right angles with, the wire attached to the crown. This plate should be so formed and bevelled that gold-foil can be solidly placed over the surface of it next to the artificial crown, and into the groove made around the cavity in the dentine along the boundary-line between this tissue and the enamel. When all is in readiness for the operation, oxychloride of zinc should be placed in each cavity, and the crown immediately put in place, and very carefully held there till the cement has so crys-

tallized as to secure the ends of the wire and plate: about an hour is necessary to such perfect crystallization as to safely admit of the preparation for and the packing of the gold-foil. The oxychloride of zinc should be left between the little plate or end of the wire and bottom of the cavity and all parts where gold cannot well be placed: this preparation also protects the dentinal fibres from thermal changes.

"One of the most satisfactory operations the writer ever performed was the insertion of a crown where a cuspid root had been extracted (unnecessarily), and the lady subjected to the wearing of a gold plate for some time. This crown was prepared and the contour filled out with foil as described (and as illustrated, Fig. 765), but gold wire No. 13 was attached to and built in with the porcelain, and placed in the pulp-chamber of the adjoining lateral incisor (which had been filled), and this same wire extended from the anterior to near the posterior proximate surface of the first bicuspid tooth, the pulp of which remained in normal condition. The crown was placed in position with oxychloride of zinc, and cohesive gold-foil was then impacted with the electro-magnetic mallet around a portion of the wire in the root and into the cavity in the crown of the incisor, and also into the cavity in each proximate wall of the bicuspid tooth, as well as around and over the wire, joining the two fillings through the enlarged fissure.

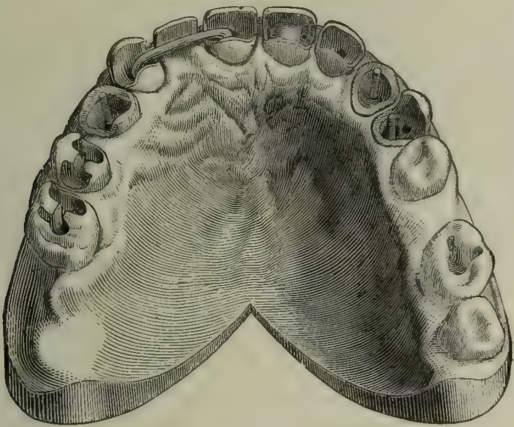
"The most extensive operation of attaching a crown to adjoining teeth was performed by the writer before the Pennsylvania State Dental Society at Delaware Water Gap, in July, 1879. In this case disintegration had taken place in many of the teeth, and cavities of decay had been prepared and filled from time to time. The teeth were abraded and the dentine was exposed along the entire cutting edge of each tooth that occluded with another. The right upper lateral incisor had been lost twelve years before. The crown of the left cuspid tooth was missing, and but a small portion of the enamel and dentine of the first bicuspid upon either side remained. These last were of course pulpless, as also were the right cuspid and central and left lateral incisor teeth, and the pulp-chamber of each of these had been filled. All the operations made necessary by the abrasion and fracture of enamel from time to time, and because of imperfection in the fillings before introduced, were performed previous to the insertion of the crown in the space left by the loss of the lateral incisor; and as this crown and each cavity and pulp-chamber was prepared for the gold, all appeared as here illustrated (Fig. 766).[1]

"Gold wire (No. 13), with a sharp thread cut upon it, was screwed into the dentine, and at the same time all the interstices between the tissue and the gold were filled with oxychloride of zinc. When crystallization had taken place, some of the cement and dentine was removed from around the wire with a small burr, and a groove was cut in the dentine near the margin of the root, so as to secure proper and sufficient anchorage for gold: cohesive foil (principally No. 30) was impacted into these parts, and the entire contour of the crown

[1] "This cut illustrates the case well, though there are parts and grooves in which to anchor the gold that are not distinctly shown. M. H. W."

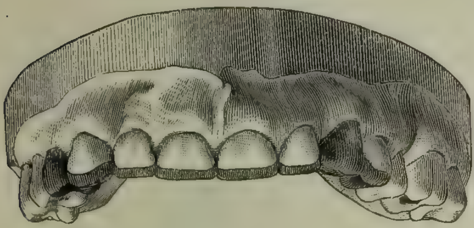
was restored with the electro-magnetic mallet. This crown was not faced with porcelain, because the teeth of the gentleman for whom these operations were performed are but slightly exposed to view; and then, too, the gold had to be placed over the enamel to support

Fig. 766.



and protect it along the cutting edges of all the incisor and the cuspid and bicuspid teeth. A gold screw was placed in the pulp-chamber and extended into the crown of each bicuspid tooth. The apical foramen of each pulpless tooth was closed, and the whole of each pulp-chamber into which a wire was not placed was filled with gold.

Fig. 767.

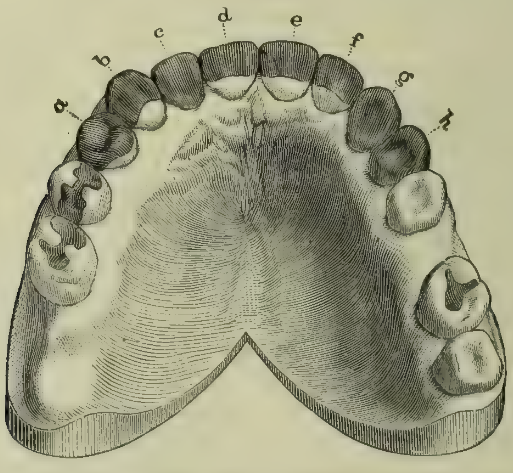


With a properly adjusted electro-magnetic mallet, carefully guided and operated with a full current of electricity from a freshly-charged four-cell Bunsen battery, the contour of each crown was restored with gold, made solid and perfect throughout: the foil was placed over the finely-prepared margins of enamel, which were not marred in the least (Fig. 767).

"The lower incisor teeth had so changed after the loss of the upper lateral that they almost closed upon the gum. This was partly owing to the abrasion of the remaining teeth, and in part due to the lower incisors gradually rising in the alveolar process. Because of such occlusion of the teeth a porcelain crown (plain 'plate tooth') with 'cross-pins' was used, and fitted and soldered to the gold wire, there being no space for a backing of plate. When the wire was prepared, the porcelain grooved and fitted to it, and ready for the placing on of the gold-foil, the whole appeared as illustrated (Fig. 766), the wire extending into each root about four lines. The cutting edge of the porcelain was removed to the same extent as that of the abraded and

prepared incisors, so as to present the same appearance and have the gold support and protect the remaining part. The wire of the crown was held in a hand-vise while cohesive gold-foil was placed solidly in the grooves, around the wire, over the cutting edge of the porcelain, and the entire contour restored with the electro-magnetic mallet. During the final fitting of the crown it was made to so rest against the gum that the blood was pressed from the capillaries of the part. When ready for insertion light medium rubber dam was applied to two teeth each side of and across the space which was to receive the crown; small barbs were made all around the wire with a sharp knife, and oxychloride of zinc was then placed in the pulp-chamber of the central incisor and cuspid, and the crown at once pressed to place. After it had been in position an hour to allow of complete crystallization of the cement, portions of this and of the dentine were removed with a small burr so as to better secure the crown and obtain anchorage for the gold-foil, then to be put in place around the wire, into each cavity, and over the prepared margins of enamel. Principally No. 30 gold (one-quarter ounce cohesive foil) was used in this case, and all was impacted with the electro-magnetic mallet, except a few pieces of light foil placed in the space between the wire and the cervical wall; and even these pieces were gone over with this very valuable instrument after they were in place. With this and all the operations completed the case appears as here illustrated (Fig. 768).

FIG. 768.

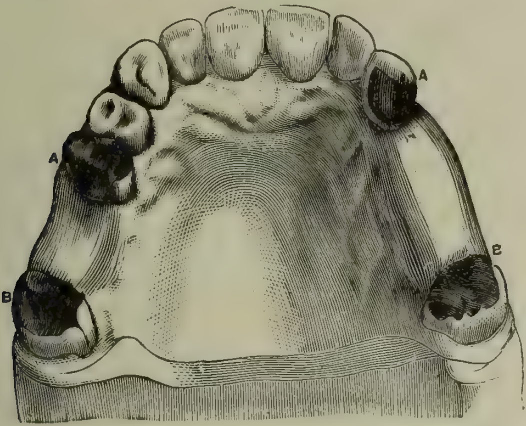


Finished Case: *a*, *b*, *d*, *f*, *g*, and *h*, pulpless teeth; *g*, whole crown restored with gold; *a*, *f*, and *h*, almost entire gold crowns; the teeth *b* and *d* support the gold crown faced with porcelain, *c*, and fully one-fourth of the crown of each of these is restored with gold, as is also that of *e*, the pulp of which is living.

"All those who have the ability and who will work earnestly and conscientiously to properly perform the various operations described, and do their very best in every case, can so manage their practice that it will not be necessary to cause any of the patients they have charge of to wear artificial crowns mounted upon plates."

In the *Dental Cosmos* for May, 1881,[1] was published Dr. H. C. Register's account of his process for "Grafting Artificial Crowns in Lieu

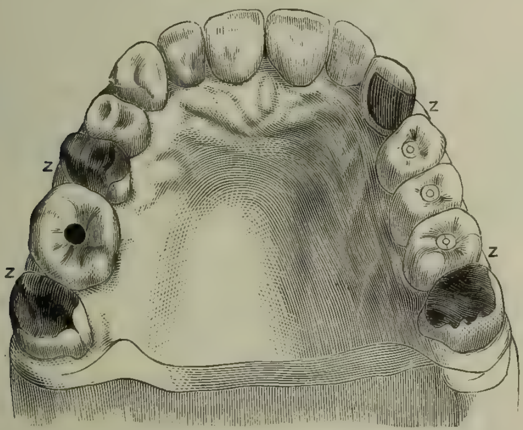
FIG. 769.



of Plates." The following synopsis by Dr. Dexter will, aided by the original illustrations, which he has lettered, give a clear idea of the details of this process:

"Taking a typical case (Fig. 769), a rim or saddle of gold, platinum,

FIG. 770.



or iridinized platinum is struck to fit the spaces between the teeth A and B. To this are attached bars, X, Fig. 771, to enter the fillings at Z, Z (Fig. 770). Posts or pivots (D, Fig. 771) are soldered upon this saddle where the artificial teeth are to be placed, their free ends being threaded to carry the nut E. Hollow crowns, countersunk for the nut at G, and having the

FIG. 771.

[1] Vol. xxiii. p. 257.

necks ground to reach over the saddle and press upon the gum, are fitted over each post. Amalgam is used to fill in the space between the post and the tooth-wall, as in a Bonwill setting, and the crowns are drawn to place and held with the nut. The saddle is fixed in its place in the mouth, before the crowns are finally attached, by filling into the cavities z, the bars x, x."

Dr. M. H. Cryer in the *Dental Cosmos* for July, 1882, gives the following account of bridge-work cases:

"In the mouth of a student at the Philadelphia Dental College, where the first right superior bicuspid was missing, and there remained a portion of the root of the second bicuspid not strong enough to sustain a crown, and likewise irregular as to position in the arch (see Fig. 772), the following operation was performed: There was a cavity on the disto-palatine surface of the cuspid and a mesial and crown cavity in the first molar. The above-mentioned root was treated and prepared as for filling. An impression of the parts was taken, and casts made showing the articulation with the lower teeth. A piece of slightly-flattened platinum wire was fitted into the root for a dowel. A small portion of the cast was trimmed off, so as to cause the neck of the artificial crown to bed into the gum. A piece of thin platinum was burnished over the root and the vacant space corresponding to the original position of the first and second bicuspids, and a hole made through the platinum to accommodate the pin which was to be inserted into the root. The pin was now passed through the plate into the root, and treated as previously described in crowning with a plate-tooth. Two cuspids were selected, shaped, and backed with platinum: a piece of No. 18 platinum wire reaching from the cavity in the cuspid to the cavity in the molar, and passing close to the back of the artificial crowns, was attached to the teeth and plate with wax. After trial in the mouth the appliance was invested and soldered with pure gold over the pins, stays, and transverse wire (see Fig. 772). In such a case, before inserting the ends of the horizontal wire into the natural teeth, it is best to fill the cervical portions of the cavities with gold, after which adjust the dowel in the gutta-percha in the root, as before described, and complete the operation by finishing the fillings in the natural crowns (see Fig. 773). The fillings can be temporarily made of oxychloride of zinc or gutta-percha, especially if they are large, and the patient may be allowed to wear the porcelain teeth for a few days, when, if desirable, the oxychloride of zinc or gutta-percha can be removed and the cavities permanently stopped with gold.

Fig. 772.

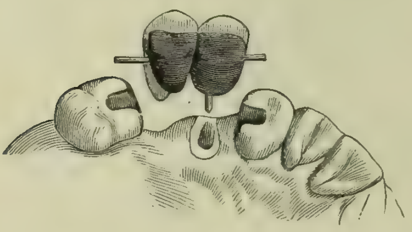
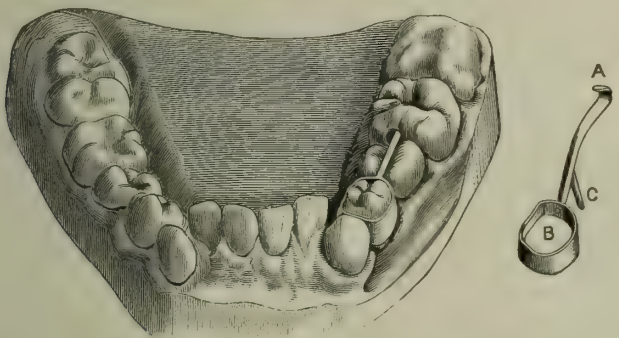


Fig. 773.

"Another case from my own practice is an example of a method by which living teeth, which have become loose through recession of the gums, may be retained in position so as to render good service. Mrs. M——, from a distant city, called to make an appointment for the extraction of a number of teeth. After examining the mouth I concluded not to extract, though the first inferior left bicuspid was so loose as to lean against the lip—an actual annoyance and quite useless for mastication. There was a cavity on its distal surface, but the pulp was vital. The second bicuspid was devitalized, and the first molar had a badly-exposed and much inflamed pulp. I did not wish to lose the first bicuspid, on account of the space it would leave, and because the gum and process would recede, thus inviting trouble in the useful adjoining teeth. The first step was to devitalize the pulp of the molar and treat the second bicuspid, putting them both in condition for filling. The excavation of the first bicuspid was attended with unusual pain—so much so as to baffle the attempt to shape the cavity properly to hold an amalgam filling. Fearing the devitalization of the pulp would add to the trouble, as the gum had already receded much, I made an appliance for holding both the filling and tooth firmly in place. A band of No. 28 platinum plate was made to fit around the crown of the first bicuspid (see B, Fig. 774), to which was soldered a piece of No. 14 platinum wire, flattened

FIG. 774.



Natural Inferior Second Bicuspid held in position by platinum anchored in adjoining teeth. A, hooked end of bar for molar; B, clasp or ring for first bicuspid; C, dowel or pin for root of second bicuspid. (The cut should show recession of gum at second bicuspid.)

and curved to form a hook at one end (see A, Fig. 774), which was adapted to the cavities in the molar, the other end extending to the cavity in the first bicuspid through a slot in the second bicuspid. To this was soldered a piece of wire forming a T (C, Fig. 774), which when all was in position would extend well down into the root of the second bicuspid. The ring or band was perforated by a hole admitting the end of the wire, and this junction secured by solder. Thus I obtained an immovable anchorage with the curved end of the wire in the molar, the T-pin in the second bicuspid, and a band around the first bicuspid to hold in place both the filling and the tooth.

"After this stay was completed the rubber dam was adjusted, the cavities dried, and the appliance placed in position. The molar and second bicuspid cavities were filled with oxychloride of zinc, and the

cavity of the first bicuspid with amalgam. Afterward enough oxychloride was removed to make spaces for amalgam fillings, which were inserted to serve as a shield to the former. The rubber dam was kept in place for two hours. Three days later the fillings were finished. This operation was practical and satisfactory, even the first bicuspid being immovable and serviceable for mastication, and it so remains to this day, six months having elapsed since the operation."

Büttner's System.

On October 12, 1882, Dr. H. W. F. Büttner of New York read before the New York Odontological Society a paper describing a method of preparing roots and forming caps for the attachment of artificial crowns, which, in cases where the body of the root has somewhat of a cylindrical form, possesses many features of excellence. Büttner's crowns are eminently well adapted for anchorages for bridge-dentures.

The following is Dr. Büttner's description of his method:[1]

"In my method of setting artificial crowns I claim simplicity of construction, firmness, durability, and arrest of decay of the root (Fig. 775). From the following description of my method it would seem that a failure would be almost impossible. To protect the end of the root from decay and to obtain a strong hold for an artificial porcelain crown, a gold band, properly applied, must be of the greatest benefit. I am aware of the fact that gold bands have been applied, but I am convinced that their adaptation after any of the old methods is defective. What I claim in my method is the preparation of the neck of the root by a set of instruments especially constructed for that purpose. These instruments enable the operator to obtain as nearly perfect adaptation between the gold band and the root of the tooth as can possibly be made. With reference to the upper centrals, laterals, and canines, as well as the corresponding lower teeth and bicuspids, there can be nothing more favorable than the application of this method. It is true that this process cannot be applied with the same advantage to the upper bicuspids or any of the molars, but I hope in time, if I am in any way supported by the profession, to solve that problem. I believe I will succeed in constructing a set of instruments which will prepare a root the pulp of which is alive, and may if healthy be readily kept so. But as this set of instruments is not quite completed, I will abstain from its description, and only allude to the setting of crowns which require the devitalization of the pulp, unless this organ has previously died. With these instruments a circular shoulder is turned on the neck of the root.

Fig. 775.

"The alteration of the neck of the root from an irregular cone to a cylindrical form enables us to adapt a corresponding ring or cap. Such a cap, when fitting accurately around as well as upon the end of the root prepared by these instruments, forms an air-tight joint, and consequently protects it from decay, at the same time giving the porcelain crown, when attached, a firmness which heretofore has never been obtained. The set of instruments by which the neck of the root is pre-

[1] From *Dental Cosmos*, January, 1883.

pared consists of drills, reamers, and trephines. The drills (Fig. 776) are used to enlarge the root-canal for the guidance of the reamer or facing instrument and trephine. The reamers (Fig. 777) cut the surface of the root down as far as necessary. They produce a perfectly level surface, and have a centre-pin which corresponds with the hole made by the drill in the centre of the root and acts as a guide. The trephine (Fig. 778) has also a centre-pin, and is used to make the root cylindrical below the free margin of the gum. A set of these instruments includes different sizes of drills, with reamers and trephines corresponding in size adapted to various diameters of roots.

FIG. 776. FIG. 777. FIG. 778.

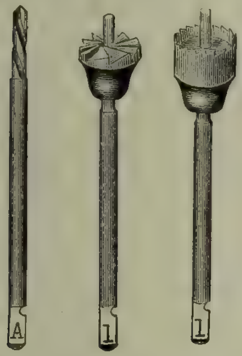
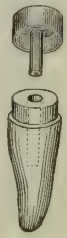


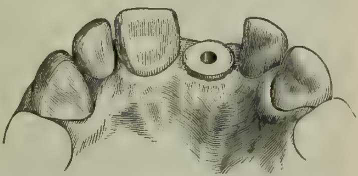
FIG. 779.



"The ferrules or caps (Fig. 779) to fit roots which have been prepared by the above instruments are of gold, made by steel dies. They correspond exactly with the trephine in diameter and depth, with allowance for sufficient expansion of the gold when forced on to the shoulder of the root, whereby a most perfect joint between cap and root is obtained. They have a stout central pivot which fits the hole in the root and gives increased strength and firmness.

"The pulp-canal is enlarged with one of the drills selected with reference to the size of the root. A reamer corresponding in size is used with the dental engine to cut the root down to a perfect level. The trephine is applied in the same manner to give a cylindrical form to it, thus completing the shoulder (Fig. 780).

FIG. 780.



"A steel wire corresponding in diameter with the drill which has been employed is now introduced into the root, projecting out about half an inch. It serves to indicate the exact direction of the root-canal. An impression-cup is selected with an opening opposite the missing tooth to take an impression of the root and adjoining parts. The object of the opening is to give free transmission to the wire in the root-canal. The wire protruding through the cup and impression-material is drawn out carefully before the removal of the impression-cup, which is then removed and the wire placed in its proper position in the impression. A set of brass root-models (Fig. 781) corresponding in size with the instruments accompanies them: one of these, bearing the same number as the instrument with which the root has been prepared, is now placed on the wire in the impression, and serves to represent the prepared end of the root on the model. The impression is now ready to be filled with plaster. After the cast is obtained we find the root-model imbedded in the plaster and the wire in its centre-hole. The wire is now removed, and the plaster cut from around the root-model to the depth of the gold cap, which is ready to be placed upon

it. A plain porcelain tooth (Fig. 782), as used in plate-work, is ground hollow on the inner surface to cover the outer front wall of the cap, thus hiding the gold. Thin platinum backing is now adapted to the tooth, which is then ready to be placed in position on the model over the gold cap, and fastened thereon with hard wax. The united parts are removed carefully from the model, invested in sand and plaster, and soldered. After polishing, the cap is ready to be forced upon the root by placing a piece of wood on the cutting edge of the tooth and driving it home with a mallet."

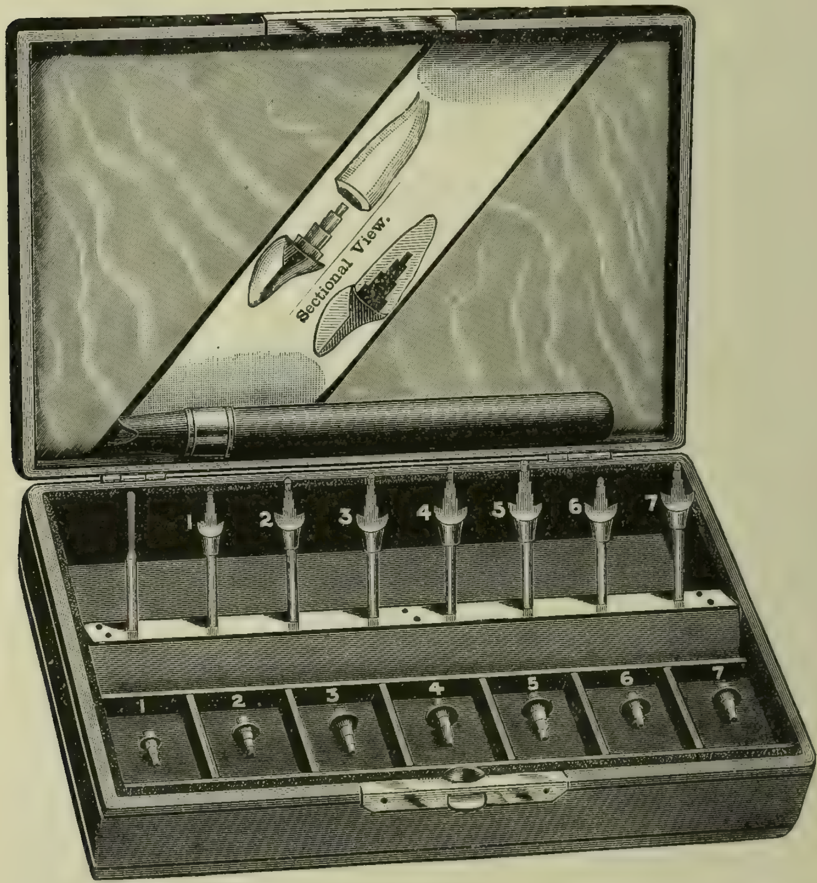
Fig. 781.

Fig. 782.

Low's System.

Dr. J. E. Low of Chicago has invented a method of making and attaching artificial crowns, which method is thus described by him:

Fig. 783.



"In our first cut (Fig. 783) we present seven instruments. No. 1,

the smallest, will be used most frequently. Any tooth generally considered beyond restoration can be crowned with this instrument.

"We now have before us in Fig. 784 a central incisor badly decayed: there is little tooth-substance exposed below the margin of the gum, the little remaining being the outer walls. The first step to be taken to place on this root a strong and serviceable crown is to cut or grind even with the gum what tooth-substance remains. We start off with the supposition that the root is in a healthy condition; if not, it must first be treated and made so, as this is the first consideration in the final result of a successful operation. The next step is to select the instrument in accordance with the size of the opening in the root to be crowned. The larger the opening in the root, the larger the inside or centre cutters must be, and the narrower the cutters that bevel and prepare the end of the root. The reason for this is that the space is nearly all taken by the inside cutters, in order to reach and cut away the decayed tooth-substance, and prepare the root to properly receive the step-plug with bevel cap which covers the end.

Fig. 784.

"We have seven sizes of instruments, and if the right one is selected no tooth-substance will be removed that ought not to be, cutting, as it does, the least where the tooth is smallest; or, in other words, we cut the opening in the tooth tapering to the shape of the root.

"These cutters leave the root in the shape of Fig. 785 with graded steps. We next select the graded step-plug, as seen in Fig. 786.

"This is the same size as the instrument, and will perfectly fit the opening and cover the end in a bevelled saucer shape, and by its attachment to the inside step-plug when cemented make a combined union of strength unequalled by any other crown, and so made as to be impossible for the root to split. Fig. 787 shows the step-plug placed in position.

Fig. 785.

Fig. 786.

Fig. 787.

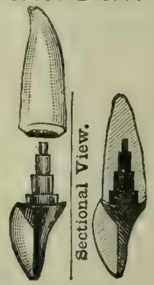
"After placing the plug in position an articulation of wax and impression of the space to be supplied and of the adjoining teeth are taken in plaster of Paris. Before taking the impression be careful that the pin which extends from the cap of the step-plug for purpose of removing is free from all roughness (a roughness that is sometimes left in the cutting of the plug), as this is liable to break the plaster when removing the impression. I generally file the step-plug on a slant from the labial side to the centre, so that there shall be no mistake in replacing the step-plug in its proper place in the impression. After placing the plug back in the impression if necessary, take a thin, heated spatula and stick the plug fast with a little hard wax on the outer edge, so that it may not be disturbed in pouring. Be careful not to get any wax on the part of the plug where you do not want solder to flow in. Now varnish the cast as usual, but do not touch the plug with varnish. Next pour with plaster and sand, asbestos, or pulverized pumice-stone, any one of which will do. After the plaster is thoroughly hardened cut it away in the usual manner. Place the articulation in the articulator and pour in the usual way. The tooth is selected, and we proceed

to back it in the following manner: First grind and fit the tooth to the cast and cap to suit you; then cover the entire inner surface with thin platinum, the thinner the better. Burnish close to the surface of the tooth. Then use 28-gauge platinum for a backing down to where the tooth is ground out to fit the step-plug, and bend the pins down to hold the two pieces of platinum tight to the tooth. We now have Fig. 788, representing the tooth as it appears backed ready to place in position.

FIG. 788.

FIG. 789.

FIG. 790. FIG. 791.



Next place the tooth in position in the cast, cover with plaster and sand, and solder with coin gold. After finishing and polishing, the crown is ready for adjustment. Moisten the step-plug and cap with cement, as in Fig. 790, and with the little rotor, seen in Fig. 789, gently press the crown up in position, and we have the crown completed as seen in Fig. 791.

"If you desire a cheap crown, solder with block tin. After experimenting with various metals, I have succeeded in making a step-plug—or tip, as I usually call it—of platinum and nickel that is as strong as steel and cannot be melted.

"In the above description you have my way of making the crown. Given in detail, it seems like a long and tedious method, but it is very short; and, as I always keep a laboratory-man, not twenty minutes of my time is consumed in making and setting a crown. I only prepare the root, take an articulation and impression; then, with the shape of the tooth, I hand all in to the laboratory-man for finishing. When my patient returns, providing the crown is not made while I am doing some other work for him, it takes me from ten to fifteen minutes, counting the setting of the cement, to adjust the crown. This is my manner of setting the crown to save time at the chair.

"If I perfect the crown myself, I take a shorter way: After preparing the root with the instrument and placing the step-plug in position, my tooth is selected, ground, and arranged in the mouth, after which I back the tooth as before described. I warm and stick to the backing of the tooth a small amount of sticking-wax made of rosin, gutta-percha, and beeswax, and place the tooth in position in the mouth, perfectly imbedding the top of the step-plug in the wax. Great care must be exercised to have the tooth in the position desired and in pressing the tooth and wax against the plug. I next carefully remove the wax and tooth, and with pliers remove the step-plug and place in the impression just made. Then with a heated spatula I stick the tip and wax

together, pour in the usual way, and in a few moments it is ready to solder. Thus a crown can be set easily in one hour's time.

"If you wish to crown a bicuspid or a molar, your first step is to grind the tooth-substance even with the margin of the gum, and then use your drill. In drilling, instead of following the nerve-cavity direct, which would leave the instrument a little diagonal, hold the instrument perpendicular. This leaves the upper portion of drill to the outer wall of the root, and brings the lower portion of the drill to the inner side of the root. You would puncture the wall of the root if you went deep enough, but there is no need of going to such a depth. Next take No. 1 cutter, which will invariably be the instrument to operate on all the bicuspid and molar root-canals, and after carefully cutting to the depth desired the root is ready for the introduction of the step-plug of same size. We now drill one other root in the same manner, and after placing the step-plugs in position take an articulation and impression, remove the plugs and place in the impression, pour and separate, and place in the articulator as before described. We have, with the adjoining teeth, an exact impression of the root to be crowned.

"Next take a thin piece of platinum, and make two perforations for the pins on the ends of the step-plugs to enter; press the platinum down over the root and burnish close to it; then remove and trim by the marks made in burnishing to the exact shape of the root. Place the platinum on the root again, and we are ready to select our tooth. This should be made the same as is used for bridge-work, with gold cusps, so no breakage can possibly occur. Place the tooth in position in the articulator and hold in place with wax. Encase in plaster and sand, and fill in and solder with coin gold, or, if you choose, block tin can be used. After polishing and burnishing you have a strong, durable crown ready to be adjusted, only equalled by the natural tooth.

"In setting a bicuspid we seldom use more than one step-plug, and the process is similar to setting a molar.

"Fig. 792 shows the root cut ready to receive the step-plug. Fig. 793 shows us the step-plug with the platinum covering the entire tooth-surface. In Fig. 794 it will be seen that the cap to the step-plug goes

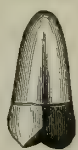
FIG. 792.

FIG. 793.

FIG. 794.

FIG. 795.

FIG. 796.



below the surface of the tooth, leaving tooth-substance all the way round, but the platinum that is soldered to the step-plug rests on the tooth-surface. In Fig. 795 we see the crown ready for adjustment. Fig. 796 is the tooth after it has been adjusted.

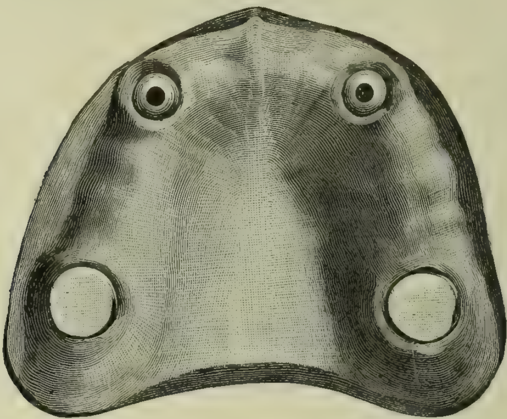
"These plugs can be used to great advantage in varied dental operations. There is nothing equal to them for restoring broken and decrepid teeth to their original shape, appearance, and usefulness. I use them exclusively in bridge-work. They make a firmer, stronger, and more

durable groundwork for bridging than any other method I have ever discovered. In badly-decayed molars, where there is not sufficient tooth-substance to hold a gold crown for a bridge, I always place one of these plugs in the root to constitute a solid foundation. If the pin on the end of the plug for removing is not long enough, it can be very readily lengthened by soldering a piece to it, and this without danger of injuring or melting. The plugs are made of a perfectly non-corrosive metal, though the color might indicate otherwise. They are strong as steel, and cannot be melted by any heat from an ordinary blowpipe."

Of the application of this crown to bridge-work Dr. Low gives the following description:[1]

"For the first illustration, as seen in Fig. 797, we have a case where

FIG. 797.



all the teeth have been extracted except the two cuspids and two second molar roots.

"We first proceed to prepare the roots by crowning. I use gold crowns on the molar teeth and the Low crown on the two cuspids.

"The preparation of the two cuspids consists in making the crown ready for adjustment. I always measure the tooth to be crowned with gold with a strip of block tin, about 35 Stub's gauge. Place the tin around the tooth, and with pliers carefully measure the full size of the same.

"Should you be measuring a tooth or part of a tooth on which there are projections, take the engine and with a stone grind off the same, making a smooth surface, so there will be nothing to interfere with the proper fitting of the bands. After cutting the tin measures by the marks made by the pliers, you have the measures ready to make the gold bands by. Cut the bands and bevel the edges and solder together, and you are ready to fit. After fitting all the bands and finishing the crowns in the usual way, I place each in position in the mouth, having previously regulated the articulation of each crown as desired in the process of making. I now take a deep articulation in wax and impression in plaster of Paris; remove before it gets too hard, and place all

[1] See *Ohio State Journal*, June, 1886.

the crowns in their positions in the impression; varnish, oil, and pour in the usual way; separate the cast from the impression and place in the articulator. Then pour plaster. After the plaster has hardened remove the wax, and we have the articulation proper and are ready to select and grind our teeth, having previously selected our shade. My experience has long ago taught me that no porcelain teeth can stand the pressure for bridge-work, the strain on them being twice as great as with teeth on plates, which rest on the gums, that give to pressure. In order to prevent breakage of teeth and give strength I have for many years been making a tooth with gold cusps. I will here describe my manner of doing so.

"I had some shells of bicuspids and molars made, or rather teeth, without the crown. They can now be found in some of the dépôts. For the first step I use 28-gauge platinum for a covering of the inside of the shell or just where you wish gold to flow. Then I bend the pins down to hold the platinum in position, and with a file remove all overlapping platinum to prevent breaking of our tooth in heating. The tooth is made flat on the crown surface with the express intention of restoring with a gold crown. The crown need not be very thick, but should perfectly resemble the cusps on the natural tooth for the purpose of mastication. As these cusps are not on the market, and every dentist making bridge-work cannot make it in a way to stand without putting gold cusps on the grinding surface of the bicuspids and molars, I will here describe, for the benefit of those who do not know how to make them, how they can be made with very little trouble. Pick out a natural tooth with cusps the exact shape you wish to have your gold cusps; mix some fireclay in a thick paste, then press your tooth into it a little deeper than you wish the cusps. Having made the proper impression, remove the tooth, and set the impression over the gas-stove to dry. After it is dried and reasonably hot, lay your pieces of gold in the impression and with a blowpipe melt them. When melted, press with a piece of steel on the gold till cool. This mould will do to make many from. If you have not the fireclay, and can get charcoal that is burned from fine-grained wood and is soft, you can simply press your tooth into the charcoal and melt in the same way, or you can carve your teeth as you desire in a block of carbon. Of course the little steel dies are handier, as we can swage up our gold cusps in them, either solid or thin.

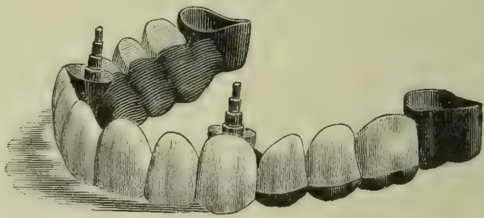
"Having described our manner of making the cusps, we will now return to the manner of finishing our tooth. I left off by saying we covered the inside and bent down the pins and filed off the overlapping platinum. We now place the cusp on the top of the tooth, and place in the position desired, holding it there with wax, and with a spatula trim the wax the exact shape we wish our tooth to be—V-shape, tapering from the crown down. We now encase in plaster and sand, which gives us a box. When hard remove the wax and place over the stove, and when sufficiently dry fill in with coin gold, using the blowpipe to melt it in a solid mass, and then our tooth is ready to file up and place in position on the articulator. Fig. 798 shows the tooth in this condition.

"After our teeth are all arranged we hold the same in position with wax, remove from the articulator, encase with plaster and sand or

asbestos in the usual way. That we may have a strong case, I always use platinum wire between all the teeth, and then proceed to heat and solder. Be sure that all the gold cusps are so arranged that you can get all soldered together, as this gives us great strength. My formula for solder, which I have used for many years, and which will be found

Fig. 798.

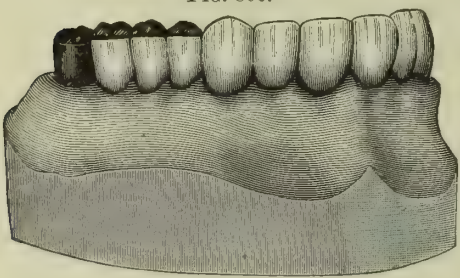
Fig. 799.



very easy flowing and almost the exact color of the gold you are using, is as follows (always figure from the carat of gold you are working): Take one pennyweight of coin gold, two grains of copper, and four of silver. We now have our case soldered; after filling as desired, commence to finish with felt wheels and pumice-stone, after which use rough buff wheels. We are now ready to adjust in the mouth. In Fig. 799 we see the case ready for adjustment.

"Have the assistant dry all the teeth or roots to be operated upon while you are mixing the cement. Be sure and use a kind which does not harden very rapidly, or your cement will set before you get your teeth adjusted. Use sufficient cement to fill all the gold crowns perfectly when the case is driven to place. Moisten the step-plugs and cap with cement, touching every portion, and with an instrument place a little cement in the bottom of the cavity. We now adjust our case, using the little rotor for the Low crowns and a piece of ivory for driving on the gold crowns. Fig. 800 represents the case when in position.

Fig. 800.

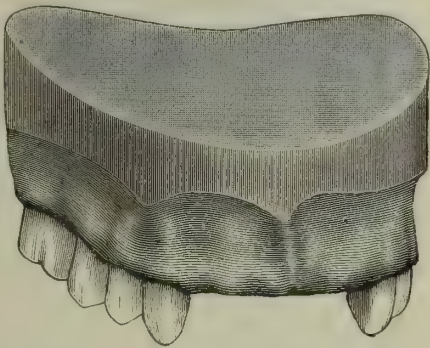


"It will be seen by looking at Fig. 799 that the teeth after having been soldered are all spaced fully one-third of the distance from the place of contact with the gums and the grinding surface of the teeth, so that the secretions could not possibly lodge there. I have given you a description of my manner of making a full upper case of bridge-work where there are roots to be crowned to support the bridge. I will now describe my manner of operating upon a case where the four centrals are missing, as seen in Fig. 801. To supply these four teeth where the cuspids are intact, I use a gold band. I first measure the tooth with strips of tin, and make the gold bands, as before described, and cut out the outside lower portion of the band before beginning to fit. In fitting,

as the band is being driven down cut away any of the band that touches the gum before all touches; never drive the band under the gum, as inflammation would probably follow.

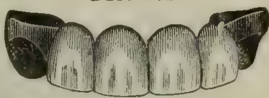
"I mention this, as I have seen many attempts to get rid of the bands by driving up under the gums and cutting them out on the front, until they were too narrow for strength. It is hard work to make something out of nothing. The bands should be heavy and strong, and the patient made to understand that if he expects to get rid of the annoyance of the plate he must sacrifice his dislike to showing gold. After driving the bands up close to the margin of the gums, as the cuspid teeth are very tapering, the bands will have to be taken in at the bottom. To do this I slit the band about a third of its length up, then place it on the tooth again, lap it over enough to bring it to a close fit, and then take it off and solder.

FIG. 801.



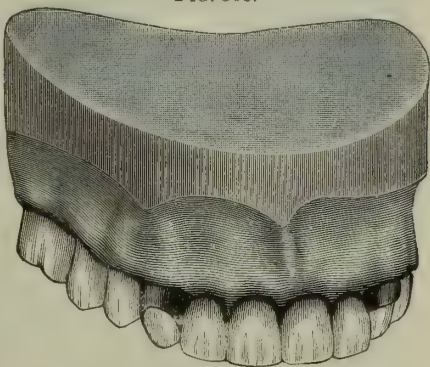
"Continue taking it in wherever it does not perfectly fit the tooth, and after a good fit is obtained, proceed as before described by taking an articulation and impression. In adjusting first try the case on to see that it fits and that the articulation is all right. Fig. 802 shows the case ready for adjustment.

FIG. 802.



"Next have the assistant dry the teeth upon which the bands are going, and then mix your cement. This should be mixed to about the consistency of thick cream. It must be neither too thick nor too thin, or the adhesion will not be strong enough to hold. Cover your teeth with cement, and then the inside of the bands. Place these on the teeth and carefully mallet up into position. For this purpose I use a steel instrument with a crease or groove in the end. The teeth must be kept dry after the case is in position until the cement is well set. After this is done bevel the edges of the bands and burnish close to the teeth, and if properly done they will be made to resemble gold fillings. In Fig. 803 we have the case completed.

FIG. 803.

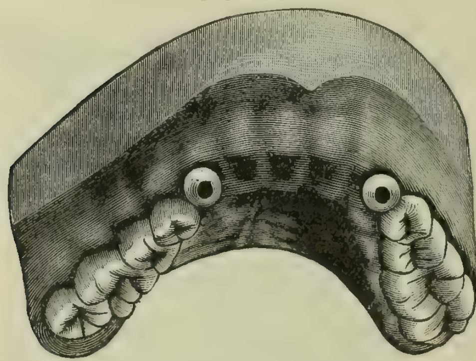


"I am aware that in a case like this porcelain crowns instead of

gold bands could be used, and I should consider it much preferable to do so where we have roots or unsound teeth to operate upon; but I do not advise the destroying of nerves where the teeth are intact to supply such a case with crowns, as the bands will answer every purpose for many years.

"If they should give out in after years, the roots can then be crowned. I have many of these cases that have been in use seven and eight years, some of which have never loosened, and some I have reset nearly every year. I always impress upon the patient the necessity of having them reset immediately should they become loose, and advise them to have their cases examined at least once a year. Should parties insist upon having crowns used to supply a case like the one just described on perfectly sound teeth, I should begin by using an aluminum disk with corundum, cutting deep as possible both on the labial and lingual sides, and then use the excising forceps. This can be done under the influence of an anæsthetic or otherwise. It is not by any means so painful an operation as one would think. If the nerve does not come out with the piece of tooth cut off, I take a piece of orange-wood which I have previously cut the proper shape to drive into the nerve-canal. I place it in creasote, and let it soak a few minutes before beginning to operate. Immediately after severing the tooth drive this into the canal, then remove and dip in creasote, and drive in again. This will perfectly fill the nerve-canal; all sensitiveness will disappear, and you can begin to operate at once. I do not recommend this treatment for sound teeth, but I have treated many exposed nerves in this way, also many teeth broken by accident, and think this the most satisfactory way to dispose of such cases. I have never had any unfavorable results follow after operating upon teeth in this way, and I can hardly say as much in favor of any other treatment. I speak of this manner of treating exposed nerves as one of the operations that sometimes become necessary in adjusting a bridge properly. I do not claim any originality in this mode of treatment. I know several dentists who use this method, all of whom report satisfactory results. We now have Fig. 804, showing the roots prepared to receive the case.

Fig. 804.



"I have many of these cases in use that are giving entire satisfaction. The instrument selected for preparing these roots should be one with small inside cutters and large bevellers, so as not to cut away any more tooth-substance than possible.

"Fig. 805 represents the case ready for adjustment; Fig. 806 represents the case after adjustment.

"In this article I have described my manner of making teeth for

bridge-work. I am now having made a tooth expressly for bridge-work, which I hope to be able to place on the market soon. I have

Fig. 805.

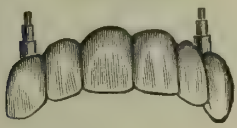


Fig. 806.

been using these teeth, but have not perfected my shells and moulds sufficiently to enable me to get them out in large quantities.

"Fig. 807 shows us a socket. This I propose to have ready made in various sizes in bicuspids and molars, with corresponding shells. Figs. 808 and 809 represent the shells placed in sockets. Fig. 808 is a molar tooth showing the shell in position, and Fig. 809 is a central reversed. Fig. 810 represents the socket as made for the four central and two cuspid teeth. The advantage of these teeth can readily be seen, not only for bridge-work, but all gold plates. A

Fig. 807.

Fig. 808.

Fig. 809.

Fig. 810.

Fig. 811.

tooth, if broken, can readily be replaced without removing the bridge or cracking by soldering, and with only a small expense. Fig. 811 represents the shell placed in position in the socket, which can be used for bridge- or crown-work, and will greatly reduce the labor in making either."

"A New Bridge-Denture."

Dr. R. Walter Starr, in the *Dental Cosmos* for April, 1886, gives a description of "A New Bridge-Denture," as follows:

"It will doubtless be admitted that in some cases bridge-work has advantages over the ordinary plates for partial dentures. It will also be conceded that the security and permanence of the fixture enhance its practical value to the patient so long as all goes well. But if for any reason it shall become necessary to remove the bridge, for repairs or treatment of the roots used as anchorage, its fixedness proves a serious objection.

"In the endeavor to provide a remedy for this defect the structures now to be described originated, and will, it is hoped, be found applicable in many instances in such cases as are typified by the accompanying illustrations.

"In the construction of such bridges the first thing to be done is to grind with engine-corundums the overhanging edges and sides of the teeth which are to serve as abutments, so that the crown ends shall be slightly smaller, but of the same shape as their necks. This can be demonstrated by bending a piece of fine binding wire around the tooth-neck, and twisting the free ends together to form a close-fitting loop, which, if the tooth has been suitably shaped, may be slipped from the

FIG. 812.

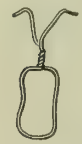


FIG. 813.

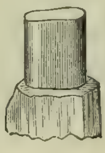


FIG. 814.

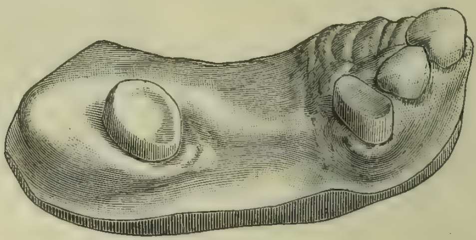
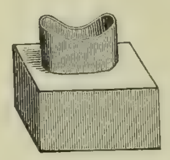


FIG. 815.

FIG. 816.



tooth without changing the form of the loop, thus giving an exact outline of its form and size. Such a loop is shown in Fig. 812. The loop is then laid upon an anvil, and the squared end of a short piece of wood placed over the wire, and a blow struck to drive the loop into the wood as a guide in shaping the wood to the precise size and form of the inside of the loop, as in Fig. 813. The free end of this wooden mandrel must subsequently be slightly reduced, so as to conform exactly to the natural crown. (These two figures were shown in a description by Dr. C. S. Case in the *Dental Cosmos* for February, 1885.) In lieu of this method an exact impression of the tooth may be taken in plaster to serve as a mandrel. About a sixteenth of an inch is then ground from the occluding cusps of the abutment teeth, and an impression taken of the teeth and surrounding parts, to obtain a model, as shown in Fig. 814. A piece of gold plate, say twenty-two-carat fine, No. 30 gauge, is cut and fitted closely around the mandrel, and its ends soldered to make a collar, as in Fig. 815. This is laid with the crown end upon a piece of lead, and a piece of wood or metal laid over it and struck with a hammer to drive the collar into the lead, so as to hold it securely and maintain its form, while with a smooth half-round file the neck end is shaped as seen in Fig. 816. The other end of the collar is then cut so that the depth of the collar shall a little exceed the visible length of the tooth, thus allowing the neck end when placed upon the tooth to pass beneath the free edge of the gum. A piece of gold plate, either plain or struck up in cusp form, is then soldered to the crown end of the collar. If a seamless collar is used, it can be laid upon the plate for soldering without an investment or a clamping wire. A piece of thin platinum plate, No. 36 gauge, a little wider than the space to be covered with the teeth, is fitted and burnished over the space between the abutment teeth, which have been so trimmed that the caps described will slide on and off easily. These caps are now cemented to the platinum plate, and collars made

and fitted to properly fill the space between the abutment teeth. They are held in contact with each other and with the platinum plate by running melted white wax in and between them. The whole piece may then be transferred from the model to the mouth, and stiff-mixed plaster and sand pressed into and over the collars and caps. When the plaster has set, the mass may be removed, trimmed, and the wax melted away,

FIG. 817.

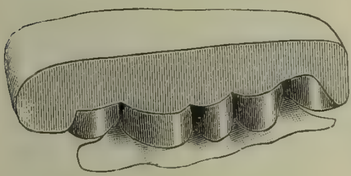


FIG. 818.

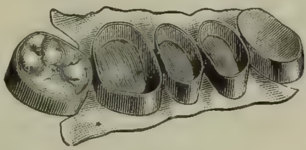
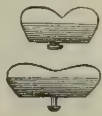


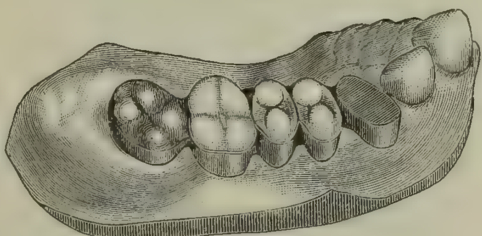
FIG. 819.



with the result shown in Fig. 817. The lines of contact of the collars with each other, with the caps, and with the plate are to be neatly soldered, when the investment may be removed, leaving the bridge as shown by Fig. 818. The free edges of the plate may then be trimmed to the margins of the collars or caps, and the whole denture polished. The bridge may now be slipped on and off the natural abutment teeth with just enough of friction to retain the denture in position, and yet allow of its ready removal.

"Suitable cusp-crowns (see Fig. 819) are now selected, the cups partly filled with wax, and the cusps placed in position. The denture is then tried in the mouth, and the proper occlusion obtained by grinding or filing the edges of the cups. The piece is now to be thoroughly cleansed and dried; the cups nearly filled with insoluble cement or hot gutta-percha; the cusp crowns set in the cups; the bridge put quickly in place; and the patient directed to firmly and repeatedly close the jaws to properly determine the occlusion. It will be found best to place a piece of paper the thickness of a postal card over the porcelain cusps when forcing the denture to place, so as to ensure that they shall be a little short, and thus avoid irritation of the anchorage-teeth in mastication. These anchorage-teeth or roots will in time elongate and form a close occlusion.

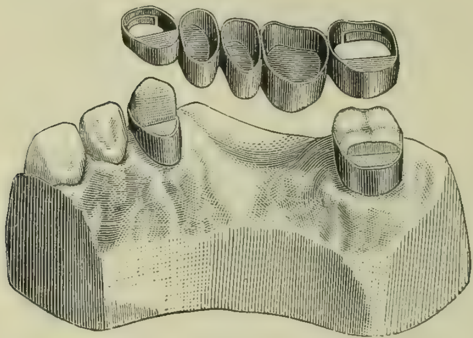
FIG. 820.



"When the cement is properly hardened the piece may be removed. A hole should now be drilled through the metal caps to allow escape of surplus filling-material. A small quantity of gutta-percha thoroughly warmed should now be placed in the caps, and with a piece of card placed between them and the occluding teeth the caps should be forced home. The completed case is represented in Fig. 820.

"The bridge may at any time be removed with warmed forceps beaks held long enough on the caps to soften the gutta-percha. The cusp crowns may be removed if desired by the same method, and replaced without detaching the bridge.

FIG. 821.



"A modified bridge is shown in Fig. 821. It will be observed that collars have been firmly fixed with cement or gutta-percha on the abutment teeth, which have their occluding surfaces ground flat on their inner aspects, so that the partial cap shown may thus prevent the telescoping collars from being forced too far down on the teeth. By means of a frame-saw a narrow tongue is cut on the outer face of each telescoping collar, the free portion serving as a spring clasp to hold the bridge securely on the abutment teeth, and still allow the removal of the piece whenever so desired. Fig. 822 shows such a bridge in place. It is obvious that if in this instance the roots only of the cuspid and second molar had been present, they could by means of the collar and cusp-crown devices have been put in shape to serve as abutment teeth for the telescoping bridge shown in Figs. 821 and 822. The second molar roots so crowned are

FIG. 822.

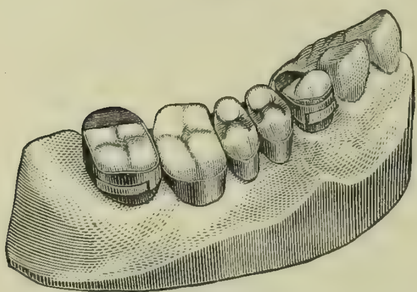


FIG. 823.

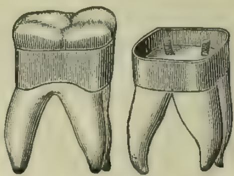
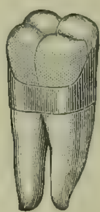


FIG. 824.



seen in Fig. 823. When it is desirable to show the faces of the porcelains to a greater degree, the collars may be cut away on the buccal sides and the countersunk crowns be used, as illustrated by Fig. 824. The platinum base may either rest broadly upon the gums or be sloped so that only the buccal border shall touch the gums, or it may be so shaped as to be entirely free from the gum. This is done by building upon the plaster cast and bending the platinum plate, and shaping the gold tubes to the surface so made, depending wholly for support on the abutment teeth or roots.

"Briefly stated, the points of excellence in this bridge are strength, lightness, avoidance of liability to breakage of the porcelain in solder-

ing, ease of construction and adaptation, and the facility with which it may be reorganized or for any reason be removed and replaced. This last feature is of special value in the not infrequent event of subsequent alveolar abscess, for in cases such as are shown in Fig. 820 the bridge may be removed, the involved teeth drilled, medicaments applied, the bridge replaced, and this process repeated without depriving the patient of the use of the denture."

"The Mandrel System."

In the *Dental Cosmos* for August, 1886, appeared the following description of "A System of Crown- and Bridge-Work" which its inventors, the experts of the S. S. White Dental Manufacturing Co., have designated as "The Mandrel System."

"In all of the various systems of crown- and bridge-work which have been brought to the attention of the dental profession one very important point seems to have been overlooked—viz. the comparative conformation of the necks of teeth of different classes. The general forms of the crowns of teeth have long been well known, but so far as we are informed no systematic classification of the shapes of the necks has heretofore been made. It will appear that such a classification ought to form the basis of any system of crown- and bridge-work claiming a scientific foundation. To lay the groundwork of the system here described a large number of human teeth of the various classes were secured, their crowns cut off, and the shapes of the stumps accurately determined, thereby developing the fact that, no matter how great differences may exist in the apparent shapes of the crowns of individual teeth of a given class, there is a remarkable uniformity in the configuration of their necks. That is, the necks of upper cuspids, for instance, were found to have a fixed type, from which the variations were very slight as to shape, though there appeared to be no exact standard of size. So of the other classes, with the single exception of the superior molars, in which two distinct forms were found, the first being those in which the buccal roots were wider than the palatal; the second, those in which the reverse condition was found, the single palatal root being wider at its junction with the crown than the two buccal roots. The occurrence of roots of the second class being rather exceptional, the first class was accepted as the type.

"The configuration of the necks of all the teeth having been determined, a set of mandrels for shaping collars to fit them was devised. The set (Fig. 825) consists of seven mandrels, six of which are double end. Their shapes are modelled upon the general typal forms of the necks of the teeth which they represent, and they are made tapering to provide for all required variations in size. The illustrations are about two-thirds actual size, the longest instruments being nine inches in length. The cross-sections show the shapes and proportionate sizes at the greatest and least diameters. The long taper permits the most minutely accurate adjustment of the collars.

"No 1 is a double-end mandrel for superior molars, right and left; No. 2 is a single mandrel for superior bicuspids, right and left; No. 3

FIG. 825.

Mandrels for Shaping Seamless Tooth-root Collars.

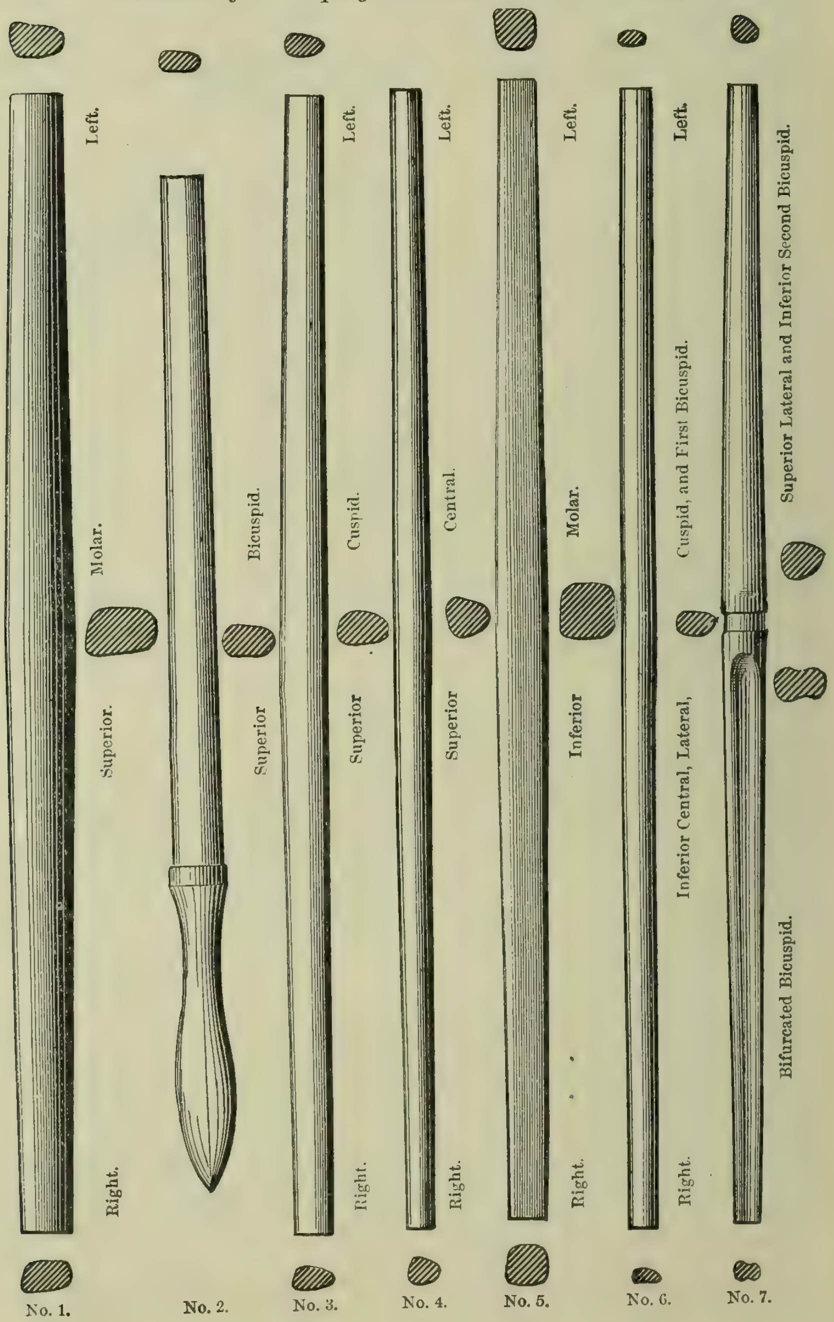
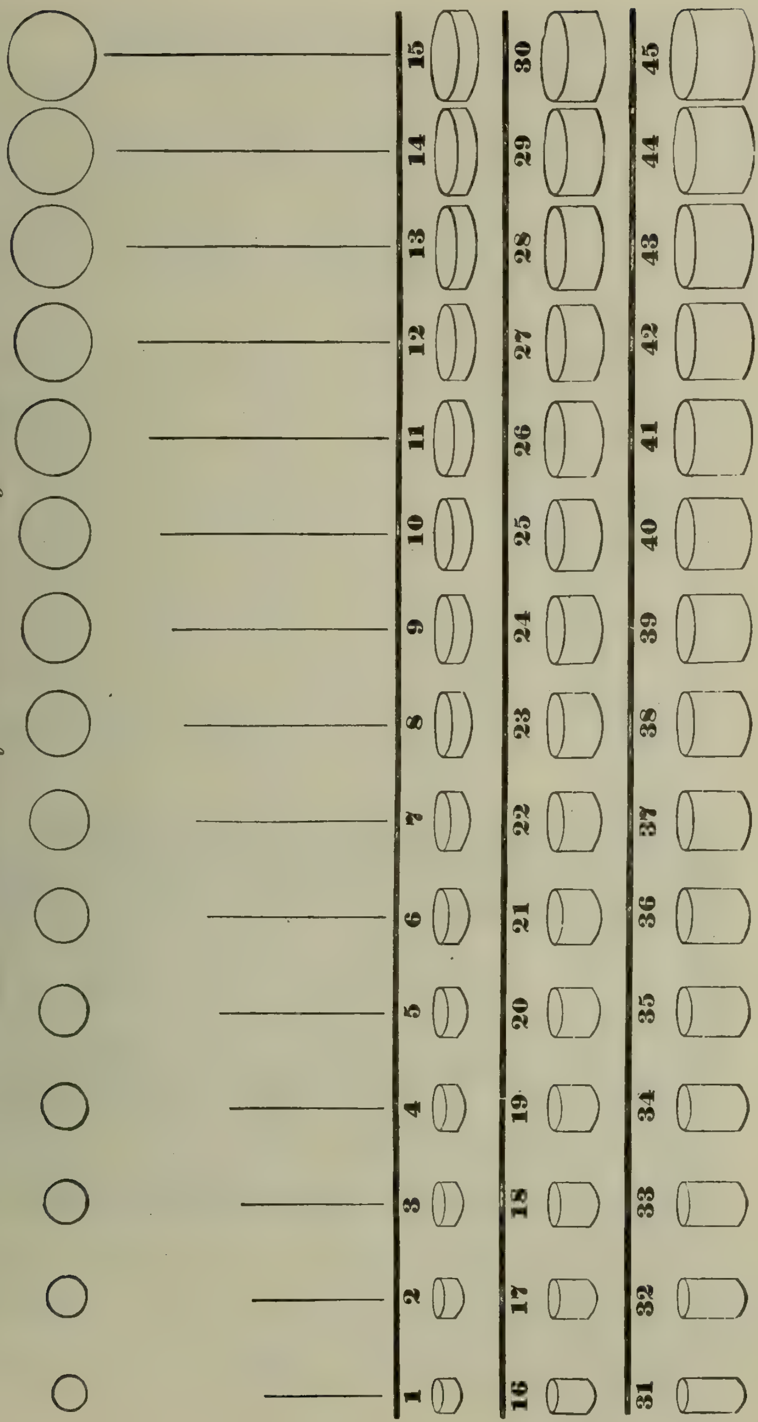


FIG. 826.

Seamless Gold Collars for Crown- and Bridge-Work.

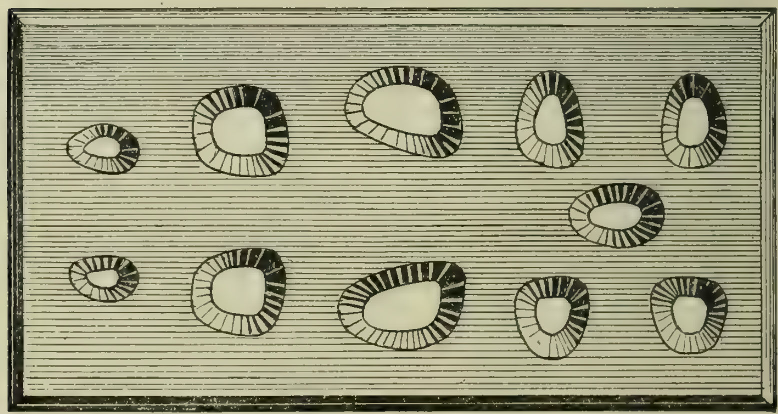


is double-end, for superior cuspids, right and left; No. 4, double-end, for superior centrals, right and left; No. 5, double-end, for inferior molars, right and left; No. 6, double-end, for the inferior centrals, laterals, cuspids, and first bicuspids, right and left; No. 7, double-end, one end for the superior lateral incisors, the other for those bicuspids in which a bifurcation of the roots or a tendency in that direction extends across the neck to the crown in the form of a depression on one or both proximal surfaces. The foregoing scheme comprehends all the teeth of the permanent set except the second inferior bicuspids. The necks of these approximate those of the superior central incisors so closely in shape that it was deemed inexpedient to make a separate mandrel, as the No. 4 mandrel will serve for both.

"The collars or bands are made seamless, of No. 30 (American gauge) gold plate, twenty-two carats fine. Fifteen sizes, each of three widths (one-tenth, two-tenths, and three-tenths of an inch) are made (Fig. 826), which it is believed will cover all requirements. These collars, although devised as a part of the system, can be used in all methods of crown- and bridge-work which require bands, and possess many advantages over any others. They are really labor-saving devices, as their use saves the time and trouble of making, and there is no danger of their coming unsoldered when the pins or the backing of the crown is being soldered; and there are no hard spots to give trouble in burnishing, as, for instance, close to the root, after the collar has been shaped and placed in position, the whole surface being uniformly soft.

"The seamless collars are also especially adapted to removable or detachable bridge-work. They are so constructed that Nos. 1, 16, and 31 exactly fit into or telescope with Nos. 2, 17, and 32, and so, on through

Fig. 827.



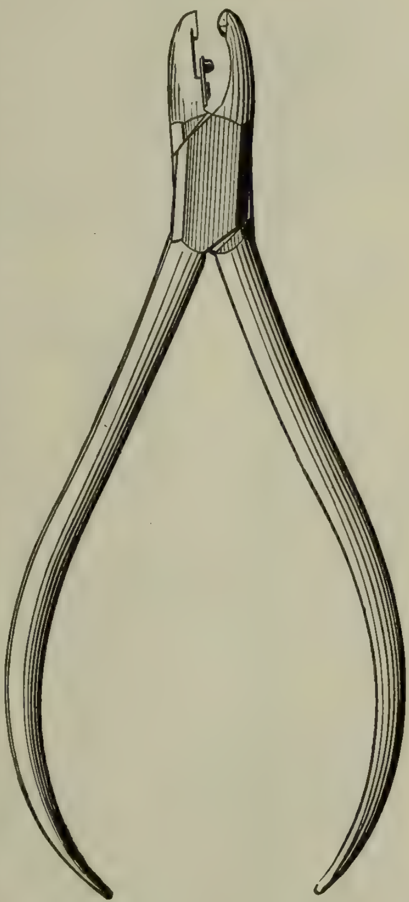
the entire set, each collar fits into the series next higher, so that a root may be banded with one size, and the size next larger used to form the tube for the telescoping crown. Their advantages for the construction of cap crowns are obvious.

"The other appliances specially devised for this system are a reducing-plate or contractor, a pair of collar-pliers, and a hammer.

"The contractor (Fig. 827) contains holes which are complementary in shape to the mandrels. The mandrels being applied to the inner circumferences of the collars, while the contractor must admit the collars themselves, the short taper of the holes in the contractor necessarily covers a somewhat greater range of size than is shown in the mandrels. With this appliance collars can be evenly and accurately reduced in size at the edges without burring or buckling. The illustration is actual size.

"The collar-pliers (Fig. 828) are for contouring the collars to shape, one beak being made convex, and the other concave to correspond. With this appliance the slightest changes required in the contour of the collars are easily made. About a half inch from the extremity of the concave beak a small bar of flat steel is attached to it by means of a screw. The free end of the bar has a minute projection upon one face, the other being reinforced to fit into the concavity of the beak. In the centre of the face of the convex beak is a depression into which the projection on the steel bar strikes, making a very efficient punch for forming guards or stops to prevent the collars from being forced too far under the gum. The depression in the convex beak being slightly larger than the projection or punch, the metal is not cut through, but merely raised on the side opposite to the punch. The punch attachment, being pivoted, can be swung to one side when not in use.

Fig. 828.

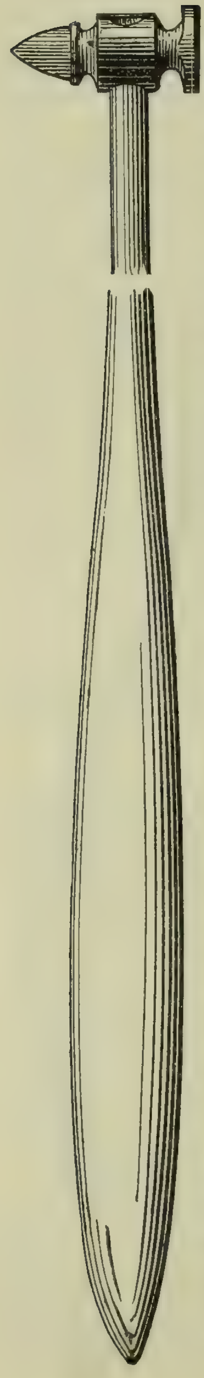


"Fig. 829 is a mallet or hammer with steel face and horn peen. The handle is nine inches long.

"One of the appliances required is a lead anvil, which being only a piece of soft lead, say two by three inches and an inch thick, is not illustrated. The female die of an ordinary case will answer very well.

"To illustrate the uses of these appliances, take a case in which the two inferior bicuspids of the left side are missing, and the crowns of the cuspid and first molar so badly decayed that the probabilities are that they will soon fall victims to the forceps. The old-time way would have been to extract the molar and cuspids and make a partial plate. Examination, however, shows that the roots of these two teeth are in

FIG. 829.



good condition, affording an excellent opportunity for the construction of a piece of bridge-work.

"With a corundum point or rotary file cut off the remaining portions of the crowns level with the gum-margins. Prepare the roots in any of the well-known ways, thoroughly cleansing the apical portions and filling them with whatever material is desired, being careful only that the work is well done. For the better retention of the filling-material to be placed in the pulp-chamber, retaining-grooves can be made or retaining-posts inserted. Take a piece of binding wire (No. 26 American gauge), say two and a half inches long; pass it around the neck of the molar stump, cross the free ends, and, holding the wire in place with one finger, twist the ends with a pair of flat-nose pliers until the wire clasps the neck closely at every point (Fig. 830). Where there are any irregularities in the contour of the tooth it is necessary to press the wire into them with a proximal burnisher. It is obvious that

FIG. 830.

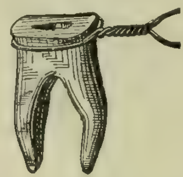
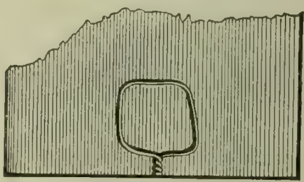


FIG. 831.

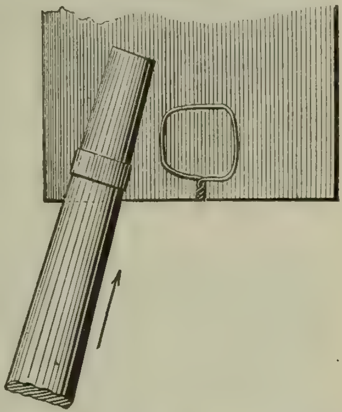


the ring thus formed will show the exact size and shape of the neck of the tooth. Remove the ring carefully, lay it on the lead anvil, put over it a piece of flat metal, and with a smart blow from a hammer drive the wire into the lead (Fig. 831). Upon removing the wire an exact impression of the ring will be left in the lead anvil. (This part of the work, as indeed all others, should be done carefully as described. The wire ring may be driven into the lead by a direct blow of the hammer face, but the blow might not strike equally, and the interposition of the flat metal held level ensures an even impression. A piece of an old file is best, as the file-cuts keep the wire from slipping.)

"Next cut the wire ring at the lap, straighten out the wire, and select a suitable collar by comparing the length of the wire with the straight lines in the diagram (Fig. 826), which show the inside diameters of the various sizes. Should none of these correspond exactly, take preferably the next size smaller. It will

be remembered that the collars are No. 30 in thickness, while the wire with which the conformation is secured is No. 26. This difference permits the collar when contoured to shape to enter the lead impression readily—a decided advantage in fitting. Having selected the collar, fit it to mandrel No. 5 with the peen of the hammer, holding it upon the lead anvil and using a slight pushing force to help in stretching and forming it (Fig. 832). Having driven the collar to form, remove it from the mandrel and try in the lead impression. If it does not fit exactly, return it to the mandrel and stretch it a little, when it will usually fit perfectly, as the mandrels have been designed carefully to the average shapes which obtain in the great majority of tooth-necks. In the exceptional cases where the collar does not fit it can be readily contoured to the exact shape with a pair of flat-nosed pliers. Of course if it fits the impression in the lead it will fit the neck of the tooth, always provided the measurement and the impression have been carefully made.

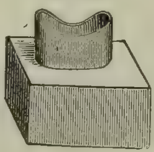
Fig. 832.



"If the collar or band has been accidentally stretched too much, or if for any reason when brought to shape it is too large, its root end can easily be reduced to the proper size by the use of the contractor. Place the edge of the collar which is to fit the root in the proper hole; hold it level with a piece of file, as in taking the lead impression of the ring, and, tapping lightly on the file, drive the collar into the plate (Fig. 833) until the proper reduction is made. The collar is next 'festooned' to correspond to the shape of the maxillary ridge. Lay it, gum edge up, on the lead anvil, and with the piece of flat file and the hammer drive it into the lead. A few cuts with a fine half-round file across the proximal diameter will conform the edges to the surface of the ridge (Fig. 834). Then place the collar in position, and, having ascertained just how far it should go down on the root, remove it, and with the small spring punch in the collar-pliers form projections on the inside of the band at the proper points to serve as stops, which, resting on the top of the root, will prevent the collar from being forced farther down upon it than is desirable (Fig. 835).

Fig. 833.

Fig. 834.

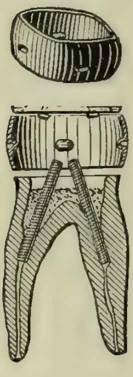


"A collar for the cuspid is then fitted in the same manner, using

mandrel No. 6 for shaping, after which the case is ready for the building of the bridge.

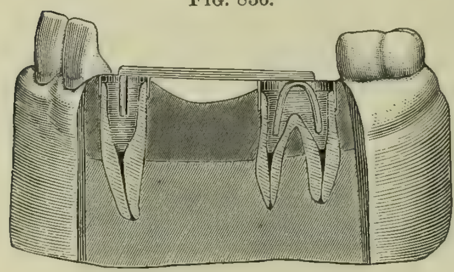
"Place both collars in position and take an impression of the parts, including the interiors of the excavated pulp-chambers, from which make a cast in the usual way. Bend a short piece of half-round gold or platinum wire into the form of a horseshoe, the two extremities of which shall fit into the roots of the molar. Then take a longer piece of the same wire, somewhat more than enough to extend from the toe of the horseshoe when in position to the cuspid root; bend one end of it at a right angle, or nearly so, to fit the root of the cuspid, and (cutting off any excess of length) solder the other end to the toe of the horseshoe. The bar extending between the two roots is the truss of the bridge. Next place the appliance on the cast (Fig. 836), holding it in position with wax, and select the teeth to take the place of the missing bicuspids and molar. The best form for this purpose is a tooth having holes extending through it vertically from the neck to the grinding surface, similar to the well-known Bonwill crown.

FIG. 835.



"The crowns used should be large enough to fill the space rather tightly, even if their sides have to be flattened slightly to let them in. If the teeth do not fill the space tightly, a small portion of plastic filling-material crowded between them, as mortar between the granite blocks in the arch of a railway-bridge, will greatly increase the strength of the work.

FIG. 836.



"After the teeth are ground to fit and the proper length for occlusion is ascertained, the truss is covered with a thin film of wax, upon which the crowns are again pressed to their positions. Upon the removal of the crowns the impression of the holes running through them will be found in the wax. At these points drill holes through the bar with a small twist drill run by the engine, and into these fit and solder the pins for the support of the crowns.

"The bridge is now ready to be attached permanently. Set the crowns in position upon their supporting pins to secure the proper alignment. (If the operation were upon the upper jaw they would have to be held with wax.) Put into the canals of the supporting roots (the cuspid and first molar) a sufficient quantity of some quick-setting plastic, as oxyphosphate, to about half fill the pulp-chamber, but not enough to prevent the supports of the truss from being forced home. Force the bridge-supports to place, and after allowing the filling-material to become set remove the crowns. Fill the remainder of the pulp-chamber and the whole of the collar with gold or with amalgam, gutta-percha, oxyphosphate, or any suitable plastic (Fig. 837).

Set the crowns permanently, the molar and cuspid first, as this affords greater facility for the trimming off of any excess of the filling-material used in the attachment. For attachment of the crowns, gutta-percha is probably the best material, as crowns set with it are readily removed for the correction of any inaccuracies of occlusion or alignment, by grasping them between the beaks, previously warmed, of a pair of universal lower molar forceps. The heat warms the gutta-percha and releases the tooth, which can then be reset properly. In attaching crowns with gutta-percha the holes in the crowns are first filled with the material, after which the crown is warmed and forced to place. Any of the other plastics ordinarily used in setting Bonwill crowns can be employed, at the discretion of the operator. Fig. 838 shows the case completed.

FIG. 837.

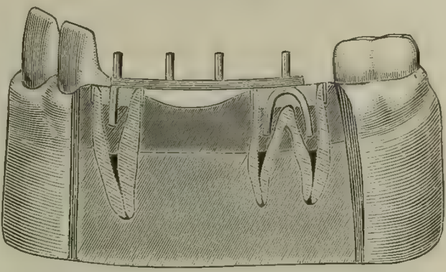
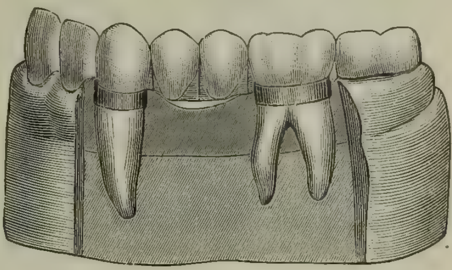


FIG. 838.

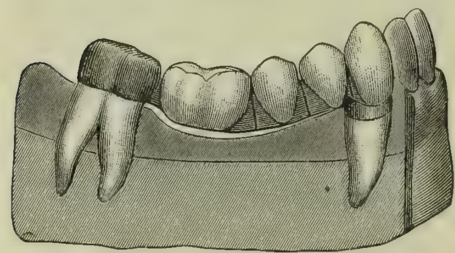


"In securing the occlusion of a piece of bridge-work it is well to make the artificial teeth a little short, so that the natural teeth on both sides will meet the first shock of mastication. Nature will correct the occlusion in time by slightly elongating the roots supporting the bridge. If the artificial crowns are permitted to strike the natural teeth from the first, the undue strain upon the two supporting roots may cause soreness, and perhaps more serious consequences.

"When a sound tooth is to be used as one of the supports of the bridge, a modification of the method just described is necessary. Take a case where it is desired to bridge the space caused by the loss of the right inferior bicuspids and first molar. The crown of the right cuspid is nearly gone, but the root is sound and capable of supporting one end of the bridge. The other end will be attached to the second molar, which is a sound tooth. Prepare and band the cuspid root as before; dress off the second molar crown until it is slightly smaller than the neck, so as to permit a cap to be telescoped over it, and take the measure of the crown with the binding wire. Select a suitable seamless collar of sufficient width to extend from the neck to a little beyond the grinding surface, and drive it up on the proper mandrel to get the general shape, but not the full size required to fit the tooth, leaving it so that the edge having the larger circumference will just pass over the end of the crown; place the collar on the tooth, and with a block of wood and the mallet tap it to place just beyond the free margin of the gum. This method will make a close fit, as the collar will readily

stretch all that is necessary. With a sharp-pointed instrument mark the length of the crown, remove the collar, and cut it to the proper width as indicated. Then in a piece of gold plate of the thickness used for caps form four little depressions of the general character of an impression of the molar cusps. An easy way to do this is to lay the plate on the lead anvil; then with the ball on the end of an ordinary socket-handle and the hammer the depressions are made in a moment. Set the collar on the plate, borax it, charge with solder, and heat till the solder flows. Cut off the surplus plate, and a perfect cap for the molar is made. Place it on the tooth and take an impression, and thereafter proceed as before directed to make the truss of the bridge and mount the teeth, except that in this case the posterior end of the truss is to be soldered to the molar cap. For the final attachment place a little oxyphosphate or any other plastic filling-material in the cap to secure it firmly (Fig. 839), first cutting a slot in the crown end of the cap for the escape of the excess of material. Pressure upon the filling-material hastens its hardening.

Fig. 839.



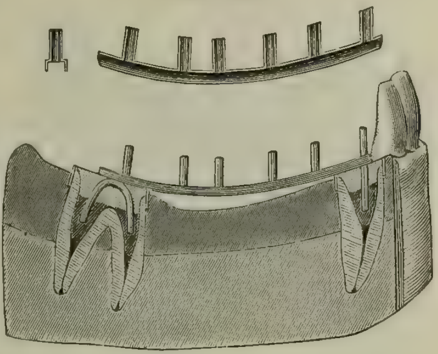
"Detachable Bridge-work.—A description of two or three methods of constructing detachable bridges will suffice to indicate the general principles involved. Having these, each operator will find it an easy task to devise the modifications necessary to adapt a method to individual cases.

"The first method is especially applicable to cases where both ends of the bridge are attached to roots; as, for example, the inferior cuspid and second molar roots of the right side, the intervening teeth having been lost. The operation is conducted as described in the first case of fixed bridge-work down to the construction of the truss, for which in this method square gold wire is used. Having cut the wire of the proper length, lay it upon a piece of gold plate (about No. 26 American gauge) of the same length and full three times as wide, and, placing the two upon the lead anvil, with a hammer and the piece of file before used drive them into the lead. This will form the plate into what we may call an open trunk which fits the square wire. Remove the two from the lead together, and, without separating them, curve to the proper shape to form the truss. Grind crowns having vertical holes, like the Bonwill, to fit, and having determined the proper points for the supporting pins (see p. 924) drill through both trunk and bar at these points. Separate the bar from the trunk and fit and solder pins to the bar. Construct small tubes to fit the pins, ream out the holes through the trunk to admit them, and set the tubes with solder in the enlarged holes (Fig. 840). Fix the crowns permanently upon the tubes. They may be mounted in any of the approved ways by vulcanizing or by the use of a plastic filling material. When they are firmly set place

the trunk with the teeth upon the bar, and anchor permanently as already described. Fig. 841 shows the completed work.

"In this method the truss consists of the bar and the open trunk which covers three sides of it. The bar is of course permanently attached to the roots of the molar and cuspid, but the trunk with the teeth can be removed at any time.

Fig. 840.



"The second method of constructing a detachable bridge is applicable to cases where one or both of the supports or piers are sound teeth. In the case adduced for illustration the right inferior cuspid crown was decayed, and both of the bicuspids and the first molar were absent. The supports for the bridge were the sound second molar and the cuspid root. After the cuspid root was prepared and banded, the crown of the molar was reduced very slightly—not sufficient to destroy the enamel, but just enough to permit a collar properly fitted to pass over it. A collar somewhat wider than the length of the crown from

Fig. 841.

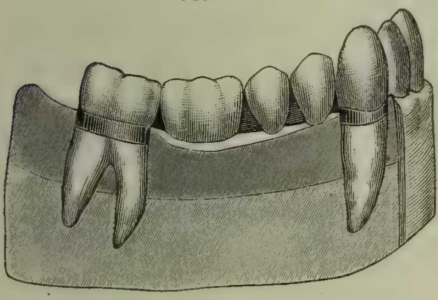
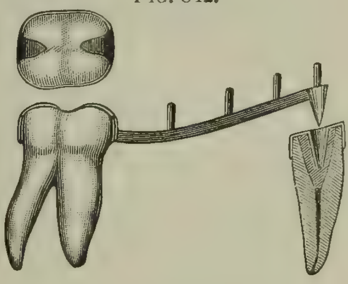


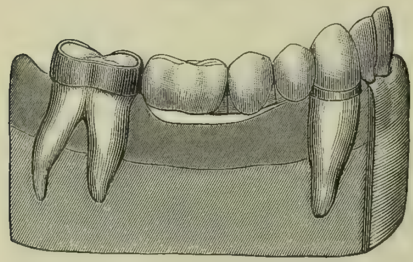
Fig. 842.



grinding surface to neck was fitted and cut to the proper width. Two lugs were then soldered upon the anterior and posterior sides and bent to fit into the proximal fissures, which were slightly cut out to admit them. An impression was taken, the collar coming away in the plaster, and a cast was made with the collar in position. A coned tube was then made for the root of the cuspid, and a coned pin fitted into it. A truss of half-round wire was made, to which the coned pin and the molar collar were soldered (Fig. 842). A half clasp to grasp the lateral was next soldered to the end of the truss, to be supported by the cuspid. The object of this clasp was to guard against the teeth being thrown out of proper alignment by the force of mastication. Bonwill crowns were then vulcanized to the truss after their supporting pins had been fitted and soldered to it. (Countersunk

crowns can be used as well in the same way. Plain plate teeth may also be used in this style of work, in which event they are to be soldered to the truss.) The bridge was then ready to be set, which was accomplished in the following manner: The cuspid root was nearly filled with oxyphosphate, and the coned tube was placed upon the pin. The band was put on the molar, and the coned pin with the tube upon it was forced into the plastic in the cuspid. As soon as this became set the tube was held permanently, while the bridge itself could be removed whenever desired (Fig. 843).

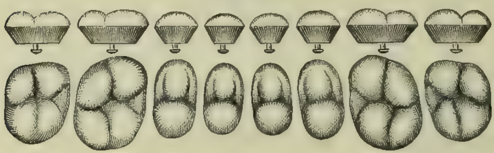
Fig. 843.



"This method of fixing the tube allows considerable range in its adjustment. In soldering the coned pin to the truss care should be taken to set it at an angle exactly parallel to the axis of the molar; otherwise there will be difficulty in removing the bridge.

"The third style of detachable bridge-work to be described involves the use of cusp crowns (Fig. 844) for supporting posts or piers. Suppose a case, similar to that described at p. 926, where a bridge is required to extend from the right inferior cuspid to the right inferior second molar, with only the roots of the two teeth named as supports. Prepare the roots and pulp-chambers. Set screw-posts into the dentine for anchorage or as retaining-pins, and fit the collars, using sizes wide enough to form the walls of the crowns. Fill the pulp-chamber and about two-thirds of the depth of the collars with a plastic filling-material, packing it well around the retaining-posts. Select suitable cusp crowns for the molar and cuspid, and place them in the ends of the bands to ascertain the occlusion. If too long, shorten the cusps or reduce the bands with engine corundums or rotary files, and when the correct articulation is found form a small square shoulder in the lingual edge of the cuspid and in the posterior grinding surface of the molar. Fill the remaining portion of the collars with plastic mixed somewhat thinner than the first lot, and set the cusp crowns in position. If there are antagonizing teeth, the mere closing of the patient's jaws will force the crowns to place. If there are no antagonizing teeth, the crowns can be readily tapped to place with the mallet, using a piece of wood as a driver. Allow the filling-material to set firmly, trimming off any excess which may exude around the collars.

Fig. 844.



"Bridge supports or piers constructed on this plan are strong and durable, and likely to withstand any strain. Take an impression, and proceed to fit seamless collars to telescope over those already set upon the cuspid and second molar roots. It will be remembered that

these collars are so made that each size telescopes into the next higher series. If the proper sizes are selected for the outside or female bands, the work of fitting is readily and quickly accomplished, forming tubes which slide easily over the supporting piers, and at the same time fit closely. It is only necessary to take care in shaping the tubes not to drive them too far up on the mandrels, and thus stretch them so as to

FIG. 845.

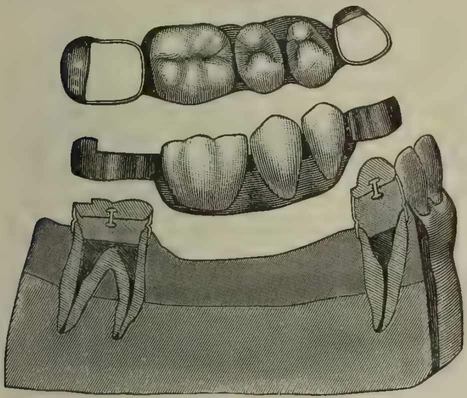
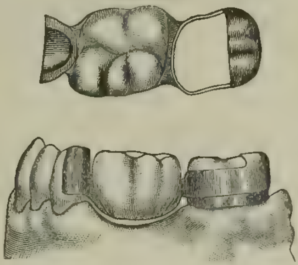


FIG. 846.



destroy the fit. To the outer end of each of the tubes solder a small piece of gold plate, forming partial caps so placed as to rest when in position upon the shoulders previously cut in the cusp crowns. Adjust a truss-bar of half-round gold wire, to the ends of which solder the tubes (Fig. 845). The truss is now ready for the teeth, which may be of any of the forms used for this purpose, and they may be attached to the bar in any way desired. One of the strongest attachments is vulcanite.

"An easy modification of the plan just described is readily adapted to cases where only a small space is to be filled and one end of the bridge is to be supported by a sound tooth. Thus, suppose it is desired to bridge a space formerly occupied by the two inferior left bicuspids, the crown of the first molar being a mere shell. The operation would be essentially the same as in the previous case, except that the sound cuspid would be utilized for one of the piers as follows: Fit a seamless collar, cut out a portion of it so that it will embrace only about two-thirds of the cuspid crown, and solder a partial cap or cover to it, as illustrated in Fig. 846. Or, if deemed preferable, the cuspid may be separated from the lateral incisor with the corundum disk, and the collar allowed to embrace the whole crown.

"The great desideratum in constructing a piece of bridge-work is, of course, the securing of perfect usefulness in mastication and speech, combined with absolute comfort and cleanliness. The closer a bridge approaches that condition where its wearer loses consciousness of its presence in his mouth the nearer perfection it is. Scarcely less important, however, is the necessity of providing for

repair. Accidents will occur, and the system which superadds to usefulness, comfort, and beauty ready facility for repairing breakages is by so much superior to those which make no such provision. A crown broken from a bridge constructed by any of the methods above described can be easily substituted, and the piece when required will be as strong and serviceable as it was originally.

"It has not been deemed necessary to detail the construction of a single crown separately, as all the steps are included in the building

FIG. 847.

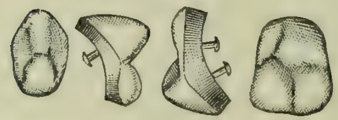
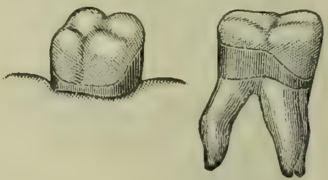


FIG. 848.



of bridges, which have been described minutely. Porcelain cusps of the general form illustrated in Fig. 847 have been designed specially for these cases. In mounting them the gold band is cut away on the buccal side, as shown in Fig. 848, to permit the porcelain to show."

"SYSTEM OF ALL-PORCELAIN BRIDGE- AND CROWN-WORK."

At the meeting of the First District Dental Society of the State of New York, held May 4, 1886, Dr. Parmly Brown read a paper describing his "System of All-porcelain Bridge- and Crown-Work," which method had been previously demonstrated before a clinic of the society. Dr. Brown's description is reported in the *Dental Cosmos* for September, 1886, as follows:

"Fig. 849 is a lateral view of a porcelain crown, with a platino-iridium pin baked in position. The pin has great strength at the neck of the tooth, where the strain is greatest, the porcelain of the tooth extending up on to the pin to increase the strength.

FIG. 849.

FIG. 850.

FIG. 851.

FIG. 852.

"Fig. 850 is a front view of the same crown, showing by dotted lines the form which the metal occupies in the crown to increase the strength of the attachment and prevent the pin from approaching the surface in thin teeth.

"Fig. 851 is a view of the two-pin bicuspid crown, which affords a

pin for each root of a two-rooted bicuspid, the staple form of the pin, shown by dotted lines, being a feature of strength.

"Fig. 852 is a view of a bicuspid crown with the two pins pressed together, making a single pin for the one root.

"The double pin in the bicuspid crowns prevents the loosening of these teeth by the rotary movements of mastication, which by means of the two cusps exert such leverage as to turn and break down the ordinary crown where only one pin is used.

"My bridge-work system has the metal baked invisibly through the body of the teeth. No metal shows either inside or outside of the dental arch. The six anterior teeth are riveted to the platino-iridium bar by the ordinary pins of plate teeth, which are the teeth used for this work. The bicuspids and molars are prepared by grinding a slot on the palatal surfaces of the teeth. The bar (which is squared for these teeth, instead of being flattened as for the front teeth) is inserted into this groove or slot, which should be ground with a thin corundum wheel to fit the bar, which can be barbed to make proper impingement. It is then ready to receive the creamy tooth-body, which at this juncture is applied to the palatal surfaces of all the teeth, completely covering the metal and giving the natural contour to the inner surfaces. A little of the tooth-body is allowed to run between the teeth, uniting their proximal surfaces.

"In this work, when cross-pin teeth are used, the pins will be ground out in most cases, but if straight pin-teeth are used, the pins will be bent over the bar. I will give a few illustrations of the many ways in which this work can be done.

"Fig. 853 is a view of a platino-iridium bar baked on to a plain plate tooth by first riveting the flattened bar on the pins, then applying tooth-body to the back, completely covering bar and pins, and then baking in a continuous-gum furnace. The body can be applied readily of a

FIG. 853.

FIG. 854.

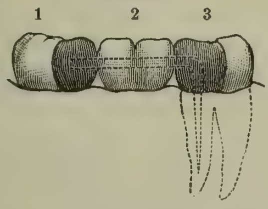
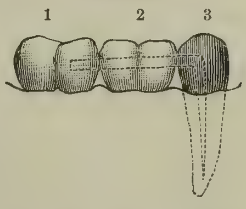


FIG. 855.



creamy consistence, and, after being held a moment over a spirit-lamp, is ready to be put on the slide and baked.

"Cavities or fillings are usually found on either side of a space made by the loss of a tooth or teeth that will allow the insertion of the ends of the metal bar and the thorough impacting of gold around them. Amalgam can be used in posterior teeth in many cases, or gold crowns penetrated by the bar, as in Figs. 854 and 855.

"In Fig. 854, No. 1 is a third molar, pulp alive, with large filling; No. 2 is a porcelain bridge; No. 3 is a first molar, pulp dead, with a metal bar entering the pulp-cavity.

"In Fig. 855, No. 1 is a second molar, pulp alive, with a crown filling of gold or amalgam retaining the bar; No. 2 is a porcelain bridge; No. 3 is a gold crown with bar passing through crown into root.

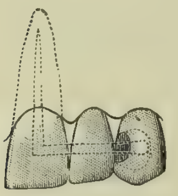
"Fig. 856 is a view of a bridge of two teeth—a central porcelain crown with a lateral baked into it, the bar and pin being of the same piece, bent at right angles.

"In Fig. 856, No. 1 is a porcelain crown forming part of the bridge; No. 2, a bridged lateral with metal bar baked through it; No. 3, a living cuspid with a metal bar running in the centre of a solid gold filling.

"Fig. 857 is a view of a central incisor bridged on to two teeth whose pulps have been lost.

"As many as six teeth have been inserted in this way on two central roots, and the posterior end of the invisible metal bar running through the six teeth worked firmly into a gold filling in a molar, the six teeth

FIG. 856.



1 2 3

FIG. 857.

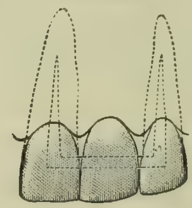
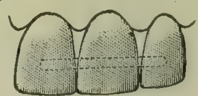


FIG. 858.



1 2 3

being united on their proximal surfaces by the porcelain running between them at the baking. The backs of such teeth must be given a curved form to ensure a cleanly condition.

"Fig. 858 is a view of the attachment of the bridge to a tooth standing alone where the tooth has a gold crown attached or the bar is worked into a filling. Nos. 1 and 3 are teeth on a porcelain bridge; No. 2, the natural tooth over which the bridge is saddled.

"All teeth for this bridge-work should be ground so that no considerable portion of gum would be covered, the teeth just touching the gum by a point only at the cervico-labial portion."

THE MATTESON SYSTEM.

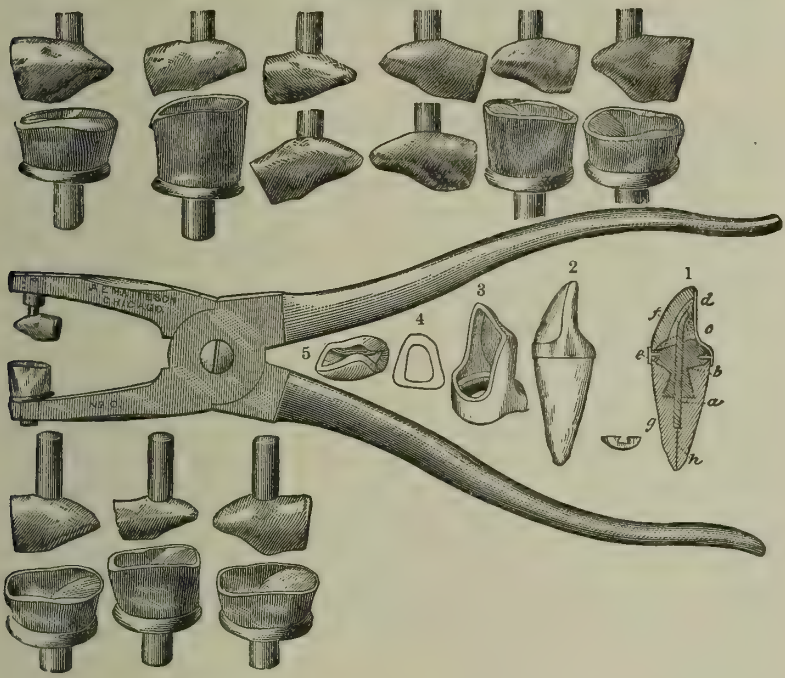
Dr. A. E. Matteson of Chicago has invented a method for making and mounting artificial crowns which possesses many features of great merit. The method as detailed by the inventor is as follows:

"The root upon which the crown is to be mounted should be placed in a healthy condition, with the pulp-canal filled at the apex, the end ground off *below* the free margin of the gum in front, and within an eighth of an inch of the gum on the inner or lingual surface, the end of the root countersunk, and the pulp-canal enlarged sufficiently to receive a platinum wire—No. 18 or 20 standard plate gauge—with a screw-thread cut thereon. This should fit tightly enough to take firm hold. Further enlarge one-half the length of the pulp-canal with a cone-

shaped burr, with its base toward the apex, as represented in No. 1, Fig. 859.

"Previous to grinding the end of the root *below* the gum in front, with fine binding wire take a measurement of the circumference of the root at the margin of the gum. Cut across at intersection and carefully remove the wire ring thus formed, *without changing its shape.* Take an

Fig. 859.



impression of its form: by placing it between a sheet of writing-paper and a smooth surface, and by rubbing the end of a finger thereon, the outline will appear. *This is the outline of the end of the root;* from this cut a pattern.

"Dissect the gum from the end of the root up to the alveolar process.

"Select a die (forms shown in Fig. 859) similar in shape to the tooth you wish to reproduce. Make a pattern of the shell by pressing between the dies a piece of pattern tin, leaving an opening in front, with a band extending around in front, as represented in No. 3, the cut being on a line with the edge on one side. Remove this pattern and press into as plain a surface as possible *without stretching the margins.*

"Cut the gold-and-platinum plate to pattern, making it wider or narrower as the wire measurement of the end of the root compared with the pattern indicates. Anneal and place the plate in the same position between the dies as that previously occupied by the pattern, and press into form; remove, bring the edges together without lapping, and solder with pure gold. The shell may be made longer or shorter,

wider or narrower, than the die upon which it was made, as the case demands.

"*To Fit the Shell to the Root.*—Trim the root end of the shell until it occupies its proper position and the articulation is correct, which is determined by the patient closing the teeth. The corners at the cutting edge and sides should be cut, and the edges brought together without lapping, and also soldered with pure gold.

"Then from platinum plate No. 28 cut the ring (No. 4) to the paper pattern. This forms the shoulder within the shell (the opening in the ring may be cut out with a plate punch). Place the shell in position on the root, the teeth closed; insert the ring, which should rest upon the end of the root midway the width of the band in front, and should fit the shell so tight that both can be removed without changing their relative positions. Remove from the root, and with a fine camel's-hair brush apply borax finely ground in water. At the junction of the two pieces place a small piece of twenty-carat solder on the inner surface—*i. e.* toward the cutting edge of the shell—to prevent an excess of solder flowing between the shoulder and the end of the root upon which it will rest. Flow the solder, which should merely tack the ring in place at the front. Try upon the root to make sure of its being correct; remove, and complete the soldering.

"The shell may be strengthened by flowing inside a lower grade of solder than previously used at such places as desired.

"Select a plain rubber tooth and fit it to the opening in the shell (which may be removed for the purpose), and with corundum wheel and disk grind a dovetailed slot in the back (see No. 5) running lengthwise, and sufficiently deep to permit the platinum screw to extend two-thirds the length of the crown without interference.

"*To Anchor the Crown to the Root.*—Place the shell in position; apply the rubber dam over it and the adjoining teeth, turning the edges well under the gum. Remove the shell; the dam will remain in position.

"Dry the pulp-canal, insert the wire screw, cut it off the required length, and with amalgam mixed hard fill around the screw in the root, and, covering the end, again replace the shell on the root (the end of the screw should be bent against the inner wall of the shell when the teeth are closed, so as to fall into the dovetailed slot in the porcelain front when that is inserted). Continue the amalgam filling, through the opening in the front of the shell, around the screw and over the shoulder, as represented in No. 1; and with oxyphosphate cement complete by filling around the wire and in the slot of the front, which is then inserted and pressed into position between the thumb and finger, the excess escaping at the edges.

"Burnish the edges of the shell around the neck of the root and porcelain front. Instruct the patient not to disturb for from four to six hours.

"In conclusion, I will offer some suggestions:

"The dies are fitted to the forceps with the cutting edges of the teeth turned toward the handle.

"Be careful that the dies and counter-dies do not get mixed. Pre-

serve the pattern of each die, with which it should be left, as it will save valuable time.

"Apply the flux (borax) only where you wish the solder to flow, and cut the solder in small pieces, using *only sufficient* to accomplish its purpose.

"Amalgam may be made to set more quickly by incorporating gold with the mercury, say 5 per cent. Foil scraps are excellent.

"In case of fracture of the porcelain front remove the pieces and fit in another, without removing the shell from the root. Cement in as before.

"The cut represents forceps one-half size. They are one-half nickel-plated. The dies are full size, nickel-plated, and are interchangeable in the screw-sockets.

"The gold-and-platinum plate is made by sweating pure gold upon a plate of equal thickness of platinum, and rolling to the desired thickness (No. 33 to 35 plate gauge), and can be obtained at the dental dépôts."

The following are some of the advantages over others which Dr. Matteson claims for his form of crown:

"The perfect joint between the root and crown, giving the greatest amount of strength where it is most required.

"Simplicity of construction and perfect adaptation to the end of the root.

"The gold-and-platinum plate gives the greatest strength without an excess of material, permitting the use of a higher grade of solder than could be employed were gold alone used, without the consequent danger of melting the shell, and, being of uniform thickness, its thorough adaptation to the end of the root is rendered a matter of comparative ease and certainty. It also permits the use of amalgam, the strongest cement we have for anchoring the crown without danger of injury to the gold. I will say, however, to those who are opposed to the use of amalgam that gutta-percha or any of the cements can be substituted, and produce as good results as in any position in the mouth.

"The opening in the front of the shell gives an opportunity to *see* that the filling is properly introduced and thoroughly condensed, and is not *guess-work*.

"The porcelain front is not dependent upon a few small pins for support, but by the dovetailed slot further supported by the edges of the shell, which entirely surrounds it, and in case of fracture a new front can be easily inserted without removing the shell.

"Of no small importance is the *ease* with which this crown can be made: even in the hands of those unaccustomed to metal-work good results may be obtained.

"The forceps, with a set of eleven dies and counter-dies, are all that is required (in addition to the instruments usually in possession of a dentist in practice)."

In Fig. 860 is shown a gold crown prepared by Dr. Matteson for a lower molar tooth, the roots of which are separated at the bifurcation. The body of the crown is attached to two ferrules fitted respectively to the anterior and posterior roots, in which, for additional security, platinum pins have been anchored. Fig. 861 shows the crown cemented in position.

In the case shown in Fig. 862 the posterior root of a lower molar has been extracted. The gold crown seen in the illustration has been formed

Fig. 860.

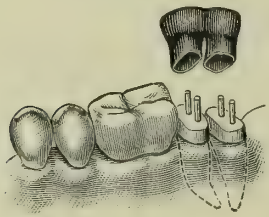
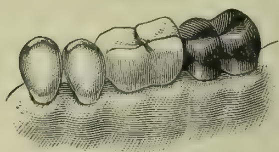


Fig. 861.



to rest upon and grasp the anterior root, fill the interspace, and gain support by close contact with the adjoining teeth.

Fig. 862.

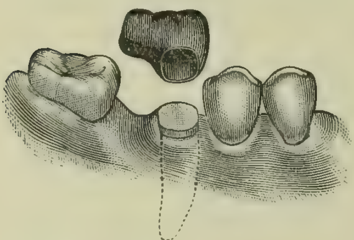
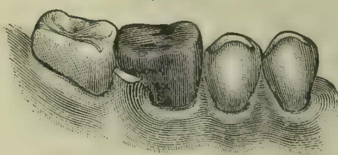


Fig. 863.



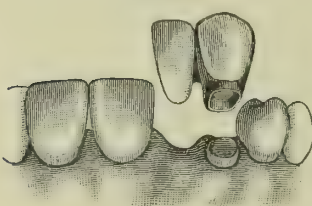
In Fig. 863 the crown is seen in position, a considerable space existing between the under surface of its distal half and the gum-tissue beneath.

Application to Bridge-Work.

The application to bridge-work of the Matteson crowns and shells is shown in the following illustrations, prepared from models furnished by Dr. Matteson for the purpose:

Fig. 864 illustrates a case in which a lateral incisor-tooth has been lost and a cuspid crown destroyed to the gum-line. To the cuspid root a Matteson crown has been fitted, and to the crown has been soldered a plain-plate porcelain tooth, suitably backed and fitted to the interspace left by the lost lateral.

Fig. 864.



In the case seen in Fig. 865 a lateral incisor tooth is seen soldered to a Matteson shell fitted to the central incisor tooth adjoining the space to which the lateral is fitted. The shell when in position (Fig. 866) slightly overlaps the cutting edge of the incisor, and also comes well around the curvature of its mesial and distal surfaces.

In Fig. 867 is seen the model of a lower case in which the four incisors have been lost. Shells have been fitted to the cuspids in such a way as to rest saddle-like upon the cutting edge of each, and pass for some

little distance over the labial aspect of each tooth. Attached to these shells are four incisor teeth, the space being thus bridged. Fig. 868 shows the bridge in position.

These shells are anchored in position with oxyphosphate cement.

FIG. 865.

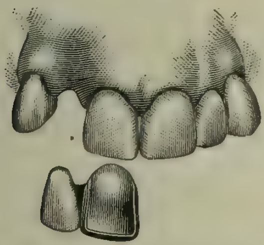
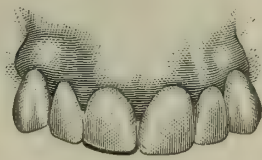


FIG. 866.



Dr. Matteson recommends that in such cases as that shown in Figs. 865 and 866 a shell be formed for the cuspid as well as the incisor, the lateral incisor being soldered to each, its position being thus made doubly secure. This he does not regard as necessary in cases in which

FIG. 867.

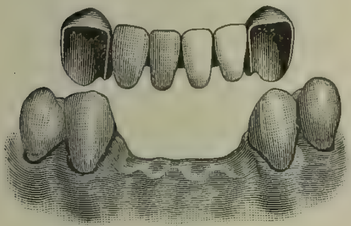
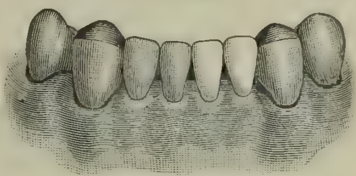


FIG. 868.



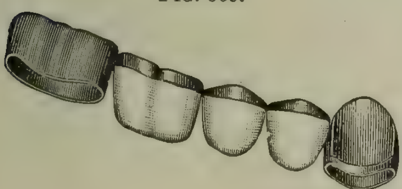
the tooth to which the shell is fitted is devitalized, as then he solders to the shell a platinum wire, attaching it in such a position that it will readily pass into the pulp-canal and increase the stability of the appliance.

ANOTHER FORM OF SHELL-ANCHORAGE.

Dr. Williams[1] sometimes uses as a cuspid anchorage for bridge-dentures a shell closely allied in its form to those employed by Dr. Matteson. The following is Dr. Williams's description of this appliance:

"Fig. 869 shows a piece of work made for a case of quite frequent occurrence. It represents the restoration of the inferior bicuspids and first molar of the right side. A gold crown is made for the second molar, and then the three intervening teeth or 'dummies' are made as described in my former paper. For the support of the anterior end of the bridge the method hitherto practised has been to excise the crown of

FIG. 869.

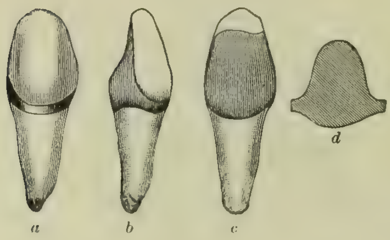


[1] See *Dental Cosmos*, December, 1885.

the cuspid and fit a porcelain crown with gold backing to the root, and to this the anterior end of the bridge is soldered.

"Fig. 870 illustrates a device which obviates the necessity for removing the cuspid crown. A gold band is fitted around the cuspid. At the front, shown at *a*, Fig. 870, this band is allowed to pass a little beneath the margin of the gum, so as to make the smallest possible exhibition of gold. On the lingual aspect of the tooth this band is allowed to be nearly the length of the crown. It will be seen that when this band is fitted as perfectly as possible there must necessarily be quite a vacancy between the upper part of the lingual surface of the tooth and the band. It is important that this portion of the band fit the tooth perfectly, and an accurate adaptation is obtained as follows: A piece of pure gold, rolled to 35 American gauge, is fitted over that portion of the lingual surface of the tooth which it is desired to cover. *d*, in Fig. 870, shows the shape that this little pure-gold plate usually assumes. It can easily be fitted perfectly by the use of a burnisher, and then, with the band in position, a drop of melted resin wax is flowed into the space between the pure gold and the band. It is now removed from the tooth, invested, and, after melting out the wax, solder is flowed into the vacancy, filling completely the space occupied by the wax. The top of the lingual portion will now be thicker than is necessary, but can be easily ground or filed down to the proper thickness. We now have a band which fits all portions of the tooth perfectly. The anterior end of the bridge is soldered to this band, and after the work is properly finished it is cemented in place in the usual manner. *b* and *c*, Fig. 870, show side and lingual views of this band after the fitting is completed."[1]

FIG. 870.



MELOTTE'S CROWN- AND BRIDGE-WORK METHODS.

Dr. G. W. Melotte of Ithaca, N. Y., gives the following description of his methods in crown- and bridge-work:[2]

"Bridge-work is the natural outgrowth of crown-work, and marks the period of the greatest advance in prosthetic dentistry hitherto made. Those who have the mechanical skill necessary for the proper construction of this class of dentures, with professional judgment for determining the cases in which they are admissible, have at hand a means of restoration which cannot fail of due appreciation, as some dentists and many patients are able to prove by incontrovertible testimony. I offer myself as a witness in both capacities, having made numerous pieces and comfortably worn a bridge which has rendered effective and cleanly service for nearly four years. I have, in fact, devoted much time and thought to this work, struggling with difficulties harder to be overcome than in any other operations, meeting discouragements and failures enough to

[1] See also p. 910.

[2] From *Dental Cosmos*, December, 1886.

develop caution, yet still able to report a degree of success that warrants a confident continuance in the work. I am therefore prepared to submit for consideration some points of improvement in the formation of crowns and means of anchorage in bridging.

"Fig. 871 illustrates a case for the supply of a lateral and a bicuspid. In this instance the cuspid could be cut off and the root collared and capped in combination with a pin entering the enlarged pulp-canal; but, as there may be grounds for objection to cutting off sound teeth, I obviate the necessity by cutting a shoulder on the lingual portion of the cuspid, and suitably shaping its sides to permit a close fitting of the collar just under the free margin of the gum. A narrow strip of pure pattern tin, bent tight around the tooth-neck and cut through with a knife at the lap on the labial surface, will serve as a measure for the length of a strip of twenty-two-carat gold plate, No. 29 thick and as wide as the length of the distal side of the cuspid. The ends of the gold are then squared, and with round-nosed pliers brought evenly together, to be held in flush contact by the soldering-clamp shown in Fig. 872. The soldered collar, with its joint side inward, is then

FIG. 871.

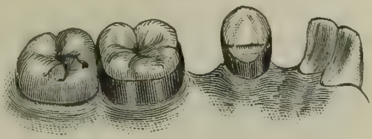
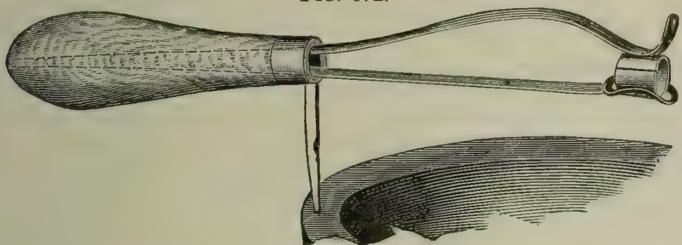


FIG. 872.



adjusted on the tooth as accurately as possible, giving slight blows with a mallet until the collar touches the gum, when it should be marked to indicate the necessary trimming to conform it to the gum contour. After it has been thus trimmed, the edges bevelled, the labial part swelled with contouring pliers, and the lingual part cut down to about one-tenth of an inch in width, the collar is again driven on, and will appear as seen in Fig. 871. A stump corundum wheel is then used to grind a shoulder on the lingual surface of the tooth, grinding also the edges of the collar flush with the shoulder. The collar is again removed, and a piece of thin platinum plate, about No. 32, sufficient to cover the lingual surface of the tooth, is caught on the lingual edge of the collar by the least bit of solder, and all put in place on the cuspid. (See Fig. 873.) The platinum should now be burnished on to the shoulder and over the tooth and collar to the extent shown by the lines in Fig. 873. After trimming to those lines, and careful replacement and burnishing on the tooth, the collar and half-cap are removed, filled with wet plaster and sand, and the platinum soldered to the gold. It

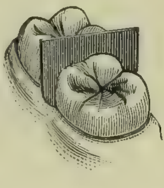
is then placed on the tooth, burnished into all the inequalities of the tooth, very carefully removed, invested, and enough solder flowed over the platinum to cover and give it strength. Fig. 874 shows it complete on the cuspid.

"I have feared that a detailed statement would imply a long and tedious process, but I have often made such collars in less than an hour; and in any case time must be made subservient to exactness of fit and adaptation to the end in view.

Fig. 873.

Fig. 874.

Fig. 875.



"In the preparation for fitting a collar on the first molar (Fig. 871) I should have wedged or otherwise separated it from the second molar, so that a piece of sheet brass might be put in place, as shown by Fig. 875, and an impression taken in plaster, which if allowed to get hard would bring away the metal. If not, it could be replaced in the plaster. Melted fusible metal when near the cooling-point is then poured into the impression, and when cold will allow the safe removal of both the plaster and the metal strip. On this metal model a collar can be formed that will accurately fit the molar, as seen in Fig. 871. If the molar has no antagonist, a cap may at once be struck up on the model; but if there be an antagonist the cusps of the natural molar should be removed by grinding at points where the occluding tooth will admit of sufficient thickness of the gold cap. An exact copy of the ground cusps can then be made in less than five minutes by the use of moldine[1] with its accessories, and the process is as follows: Make the tooth perfectly dry. Put the collar on it. Nearly fill the cup with moldine, and coat it with soapstone powder. Press the compound on the tooth and collar firmly to about one-fourth the depth of the tooth. Carefully remove the cup; trim off any overhanging material, and place the rubber ring over the cup to about one-half the depth of the ring. Melt the fusible metal, and pour it as cool as it will run from the iron ladle. As soon as the metal is hard remove it with the ring, taking care not to impair the impression, which can be used again if the die is found imperfect or gets injured in use. Place the die and ring in cold water, to remain until quite cooled. While the die is wet and held over a basin of water pour into the ring fusible metal which has been stirred until it begins to granulate, and quickly immerse all in the water. The die and counter-die should separate readily by tapping them with a hammer, but if they stick others can be quickly made from the same impression by the same method, using more care. With this die and its counter-die a piece of No. 29 or 30 gold plate is swaged to fit perfectly the cusps and collar, which, when removed, can be held to its place on the cap by the soldering-clamp, using spring pressure enough merely to hold them together for careful soldering with the pointed flame, so as not to unsolder the collar. The seamless collars are excellent when care is used in selecting the proper size as directed on the diagram.

[1] A moulding-compound prepared by the S. S. White Dental Manufacturing Co.

"The caps being in place on the cuspid and molar, an impression is taken with plaster; the caps accurately set in the impression, and hard wax melted with a hot spatula around the edges of the caps. The impression is then thoroughly coated with sandarac varnish, after which it is dipped for a moment in water, and filled with a wet mixture of one part marble-dust with two parts of plaster, using great care to perfectly fill the caps and moulds of the teeth. Wait until this mixture has become quite hard; remove the cup, and with a suitable knife chip off the plaster without marring the cast; secure a good articulating impression, and transfer it to the cast to obtain an exact reproduction of the relative occlusions of all the teeth involved. With such an articulation in hand, and with the means already described for swaging gold or platinum plate to fit the cusps and articulating surfaces of either the natural or artificial teeth, it should be within the capacity of any competent dentist to complete a suitable bridge, although there are practical points that can only be imparted by clinical instruction and actual demonstration in the mouth. Such a bridge is shown in position by Fig. 876."

FIG. 876.

BALDWIN'S METHOD OF CROWNING TEETH.

Dr. C. S. W. Baldwin of New York City contributes to the *Dental Cosmos* for January, 1887,[1] the following description of his method of making artificial crowns:

"In producing this system of crowning teeth it has been my aim to overcome the objections to some of the methods now in vogue—viz. to keep the secretions of the mouth from between the teeth and backing, which soon become offensive. I thus prevent disagreeable odors instead of creating them, as is usual in all teeth backed with gold, whether for gold plates or crown-work. It is my design to ferrule (for I shall deal only with that class of crowns) the tooth with gold securely in such a manner as to have but little soldering, and consequently no investment of the piece, with its tedious accompaniment. I thus lessen the time usually required in setting crowns and simplify the operation, so that it may be more generally adopted, and not be left to a few experts as at present.

"The *modus operandi* is as follows: Select a Logan crown slightly shorter than would be used for setting without a ferrule. Countersink and prepare the inside of a root as for a Bonwill or any ordinary crown. If the outside of the root at the margin of the gum presents an irregular surface, then with Dr. Walter Starr's reducers shape it to such a size that the ferrule may be perfectly adapted to all parts. Take an impression and produce in zinc or Babbitt metal a die, to form which take a plaster model of the root and an eighth of an inch long, and shellac it

[1] The author is indebted to the publishers of the *Dental Cosmos* for advance sheets of this paper, and also for full access to their valuable collection of illustrations.

to the point of a cone, which can be easily made by turning down a large spool, thus making the deep mould in sand into which the metal is poured. With this die strike the gold (twenty-two carat, No. 30 guage, is most commonly in use) laid upon soft lead. A few blows will produce a seamless and perfectly-fitting cover and ferrule. After trimming this to fit the festoon of the gum, drill in it from the lower side a hole for the pin of the crown, leaving the ragged edge produced by the drill. Then fill the countersunk portion in the porcelain crown with oxyphosphate of zinc, and with the gold ferrule or cap in place adjust the crown as you would wish it when completed. When the oxyphosphate is hard, you will find the ragged edge on the upper side of the cover will materially aid in removing and keeping the cap where it belongs. Unite the cover to the platinum pin in the crown with a small amount of soft solder—tin and lead—using muriate of zinc as a flux, a few blasts from the blowpipe being all the heat required. Then fill the root with oxyphosphate and firmly press to place. These caps might be made up at leisure, providing a few variations for 'double- and single'-rooted teeth. When a case is met that you cannot fit from your stock, choose a cap larger than the end of the root, and with a single clip of the shears cut to the centre of the cap, and with pliers spring together and lap the edges until the size required is obtained. Solder with gold solder by holding over the spirit-lamp, and proceed as before.

FIG. 877.

FIG. 878.

FIG. 879.

"Fig. 877 shows a root, cover, and Logan crown ready to be assembled for the soldering of the crown-pin to the cover; Fig. 878 shows the cap cemented and soldered to the crown; and Fig. 879, the completely crowned root."

THE RICHMOND "IMPROVED ARTIFICIAL TOOTH-CROWN."

A modification of his former methods of making and attaching artificial crowns has been recently introduced by Dr. Cassius M. Richmond of New York. In Figs. 880, 881, 882, 883 its mechanism is illustrated.

Fig. 880 gives a view in elevation of the crown; Fig. 881, a bottom plan or base view; Fig. 882, a section through a natural root with the crown attached; Fig. 883, a view of the "anchoring-pin" detached, and showing its bent end.

The following is Dr. Richmond's description of his improvement:[1]

"My improved crown has a metal band, *A*, of the usual construction, which is accurately fitted to the end of the root *B*. The roof of said band is formed at the rear side by a solid metallic backing, *C*—of gold solder, for example—forming a continuation of said band, and at the

[1] See "Specifications forming part of Letters Patent, dated October 19, 1886."

front side by the base or cervical end of the porcelain cap or facing, *D*. By the employment of the porcelain facing *D* a natural appearance is given to the artificial tooth-structure. I unite the porcelain facing to the other parts of the crown by fitting the basal end of said facing to or in the front side of the band *A*, and then uniting it therewith by the solid metallic backing of gold solder, for example, which is flowed around a pin or pins, *d*, imbedded in the back of the porcelain facing

Fig. 880.

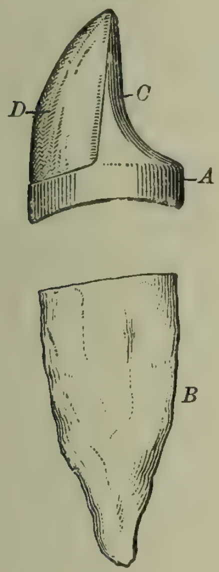


Fig. 881.

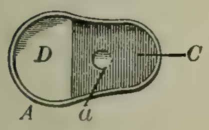


Fig. 882.

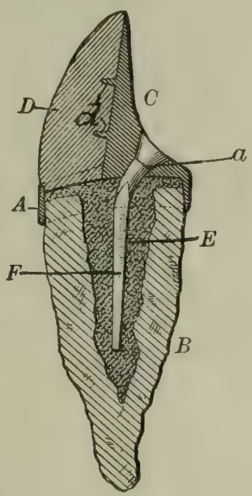


Fig. 883.

so as to form a solid metallic connection with the metal of the band. The backing thus forms a solid metallic connection between the facing *D* and the rear side of the metal band *A*, securing great strength and rigidity in the crown, while forming a cup at the base of the crown for the secure attachment and accurate fitting of the crown to the tooth-root.

"My improved crown differs from other metal band-crowns with porcelain facings in that I do not cap or roof the band entirely with metal, but form the front portion thereof by means of the lower end of the porcelain facing, and the rear portion by a solid metallic backing, and thus save time and expense and simplify the structure while

imparting additional strength. Perfectly tight joints are formed by means of the fastening cement *E*, which is employed between the crown and the root, and may be of the usual or any suitable kind—for instance, oxychloride of zinc.

"The band *A* may be made and fitted to the root, and the porcelain cap soldered thereto by the solid metallic backing in well-known ways, and these steps need not be detailed here.

"The crown has an opening, *a*, through its rear metallic wall or backing, *C*; and after the cavity in the root and the cup at the end of the crown are filled with cement in a plastic condition, the crown is pressed in place accurately on the root end, the surplus cement squeezing out at the opening *a*. I then, while the cement is still soft, force the shaft of an anchoring-post or pin, *F*, through the opening *a*, Fig. 882, and when the cement sets or hardens the crown is securely attached to the root. The upper end of said anchoring-pin is enlarged and bent rearwardly, as shown, whereby a more secure fastening is attained, a pin of this shape being peculiarly adapted to resist damaging blows or strains from the inside, from which direction they are always given. Such blows or strains are received on the end of the pin, instead of the side thereof, in my invention. The bent end or head of the pin or post *F* is cemented or otherwise secured to the metallic backing, *C*, and the structure properly finished off in well-known ways."

Casting Caps for Metallic Crowns.

The following description of a method for casting, instead of swaging, caps or crown-plates for metallic crowns is given by Dr. J. McMillen of Kansas City, Mo.:

"Take a piece of sound charcoal; cut out a small square, into which run a somewhat watery mixture of about equal parts of plaster and pulverized pumice-stone. Select a tooth of desired shape and size, and set it in the plaster mixture, sinking it as deeply as will equal the desired thickness of the cap when cast. Let the tooth remain until the plaster is well hardened, when on removing it the impress will be distinct and smooth. Dry the plaster thoroughly, melt the gold on the surface of the coal, tip the coal slightly, when the molten gold will run into the mould. While still melted place the face of a hammer or other smooth body upon the molten mass, and a crown-cap is formed thick enough to stand the wear of mastication and to admit of considerable dressing if necessary to perfect the articulation. The band is formed in the usual way, when the cap may be placed inside the band and allowed to telescope to suit the articulation. If a long crown is called for, the cap may be set upon the band and soldered fast to this position. This cap is thick enough to admit of grinding, to correct any defects in articulation, after the crown has been set. These caps can be very quickly made of any desired fineness of gold, and will be found durable." (For a variation of this process see p. 909.)

Securing Metallic Models of Teeth and Roots.

The following method for securing in a metallic model made of a fusible alloy a reproduction of the margins and face of a root is given by Dr. Barrett of Buffalo, who gives Dr. H. A. Baker of Boston credit as the originator of the plan:

"Copper is rolled down quite thin, and a band three-fourths of an inch wide wrapped about the root of the tooth and forced up under the gum. A ligature is passed around both; the copper band is burnished down, and the ligature drawn tight. The copper band will now fit just about as we want the gold band to do. Plaster of Paris is then inserted in this, forced up against the end of the root, and permitted to set. Take it off, and if you use Babbitt metal a piece of paper wrapped about it (the copper band) will lengthen it out sufficiently, when the melted metal may be poured into it, and thus a perfect model of the end of the root will be secured. That part that is inserted in the copper is the exact reproduction of the root of the tooth. The model will perhaps need a little dressing down with a file, when the gold band may be fitted around it and soldered, thus avoiding the necessity for the annoying and painful trying-on in the mouth."

As a moulding-compound for obtaining metallic models of teeth, Dr. G. W. Melotte of Ithaca, N. Y., recommends[1] potter's clay mixed with sufficient glycerin to form a stiff paste. An accurate impression of a natural tooth having been obtained in this way, fusible alloy may be run into it, and the model be thus secured. This compound might be advantageously substituted for the plaster packed in the copper band in the method of Dr. Barrett just given. Dr. Melotte's formula for a fusible alloy for making models of teeth and roots is as follows:

Bismuth,	16 parts.
Tin,	10 "
Lead,	6 " .

Crown- and Bridge-Work Hygienically Considered.

In concluding this paper a brief consideration of crown- and bridge-work from the hygienic standpoint would seem to be called for.

Objections urged against Ferruled Crowns.—The chief objection urged against artificial crowns attached to roots by means of ferrules or bands extending beneath the gum-margin is that their presence is irritative to the gum-tissue and to the peridental membrane. That this is true of large numbers of the crowns introduced is unquestionable; but in the writer's experience it is invariably due to faulty construction. Well-fitting bands, securely and neatly cemented in place, will not produce the results charged against them. When irritative effects are produced by ferrules, it will invariably be found either that the ferrule does not grasp the root closely, thus leaving a ledge like that seen in Fig. 653, p. 832, or that the edge has been left in a rough and unfinished state, or that the line of cement between the ferrule and the root has not been properly smoothed. It is clearly unjust to condemn a device because

[1] *Transactions American Dental Association*, 1886.

of the faulty methods of those who undertake to reproduce or apply it. The gum is a tissue really very tolerant of interference: its bond of union with the neck of the tooth it invests is of the slightest possible character; and it does not at all resent continued contact with a smooth, highly-polished, non-oxidizable substance, such as that of which ferrules should be, and generally are, composed.

The presence of such a foreign body beneath the gum is not at all analogous to the presence of calcareous deposits in the same position—because, firstly, such deposits are rough, and therefore irritative; secondly, porous, and therefore septic; and thirdly, progressive, and therefore encroaching more and more upon the root-investments, and increasingly or progressively injuring them. In a highly-polished metal band we have smoothness, non-porosity, and absolute immobility. Such a band, pushing away irritated and engorged gum-tissue from contact with a sharp and jagged root-edge, is not simply a harmless measure, but one which is in the highest degree remedial and salutary.

Objections urged against Bridge-Work.—As ferruled crowns for roots would seem to be, in a majority of cases, essential to the strength and stability of bridge-work, the objections urged against them would, if valid, of course be equally valid as against all forms of bridge-work of which they constitute a part. As injurious results do not follow their employment when due care and skill have been used in their construction, such objections must be dismissed as not well grounded.

Undue Strain upon Anchorage-Teeth and Roots is another of the leading objections urged by the opponents of bridge-work. That cases have been constructed in which this result followed is undoubtedly true, and yet of all the complications which arise in the wearing of bridge-dentures this is perhaps the least frequent. At first glance it would seem reasonable to assume that if, as in the model case employed for illustrative purposes in the early part of this paper (see p. 831), four natural teeth are compelled to bear the pressure brought to bear upon the ten artificial crowns attached to them, in addition to sustaining that portion of the force applied in mastication which naturally falls to their individual share, each of such teeth is doing nearly three times as much work as nature designed it to perform.

The fallacy of the assumption in question will be at once seen when we reflect that when the jaws, with the force usually employed in mastication, are closed upon fourteen teeth the force exerted is not by any means ten times greater than it would be if the occlusion was made only upon four teeth. The individual teeth are not the centres and originators each of an independent force, or, indeed, of any force in mastication; they are simply channels through which it is distributed, and the power exerted by the masticatory muscles is the same whether eight teeth or thirty-two are in occlusion. Hence our four natural anchorage-teeth in any case must bear the full impact of their antagonizers in the act of mastication, and they must bear it singly. Connect each with the others by means of the dental bridge of the model case, and it can no longer happen that a single cuspid or a single molar shall be called upon to sustain alone the force exercised by the masticatory muscles, for each and every impact of the antagonizing teeth is sustained not by one

but by all four of the teeth thus united, so that the individual teeth, so far from having three times more work to perform than before the introduction of the bridge, have really *three times less.*

This advantage does not measure the full benefit derived by the cuspid teeth from the nature of their attachment to the more strongly-planted and favorably-placed molars, because by that attachment the forward thrust which they receive in normal occlusion, and to which under certain conditions they not infrequently yield, is met and fully antagonized.

The anchoring of four incisors to the two cuspid roots when the latter are without this attachment to molar or bicuspid teeth is a more questionable practice. When the cuspid roots are large and strongly planted, and the occlusion is edge to edge or nearly so, and the mouth is well supplied with molars and bicuspids for mastication, there is but little danger of displacement; but when reverse conditions exist—that is to say, when the cuspid roots are small and not strongly planted, the "overbite" considerable, and the molars and bicuspids few in number —there is every probability that the roots will yield to the increased oblique pressure which the broader surface presented by the teeth attached to them in such cases undoubtedly favors. This difficulty, however, would be entirely obviated could the cuspids be attached to molar or bicuspid tooth upon either side; and this can often be accomplished by some such device as that shown in Fig. 750, p. 891. Discrimination is as much needed in the selection of cases for bridge-work as skill is required in their construction.

It may be urged that in the model case a well-fitting denture sustained by a plate resting upon the palatine vault and the alveolar walls of the interspaces would be preferable to the bridge, because then a portion of the force employed in mastication would fall upon the tissues upon which the plate rests, and the remaining natural teeth be thus relieved from undue pressure.

This relief, however, is at best only partial, because so long as natural teeth remain in the mouth in a fairly effective condition, so long will the wearer of an artificial plate-denture instinctively resort to them for the mastication of the more obdurate morsels of food; and when standing single and unsupported, as are the cuspids in the model case, they, as has already been stated, in time, as the result of the undue strain, very frequently loosen to such an extent as to necessitate extraction, this result being often accelerated by the denudation of their cervical margins, and sometimes the entire stripping away of their root-investments, by the pressure of the plate upon surfaces relatively so soft, yielding, and absorbable. From these mischiefs at least the wearing of a well-made bridge-denture saves the patient.

Cleanliness of Bridge-Work.—The last of the objections against bridge-work to be considered is the assertion that it is impossible to keep it in a cleanly condition. This is an objection which is altogether too sweeping. That it is far more difficult to keep clean a denture fixed in the mouth than one which can be removed and held in the hand during the cleansing process is self-evident. Natural teeth could be more thoroughly and effectively cleansed could they be so manipulated. It may, however, be safely asserted that a properly-made bridge-denture fixed

in the mouth can be just as readily kept clean as can the natural teeth. The same amount of care is needed with each. Any denture, in or out of the mouth, may be kept in a filthy condition by carelessness or inattention. Bridge-work to be cleanly must be so constructed that the brush will reach every part. If it rests upon or touches the gum at all, it must be only at the narrowed possible margin. All broad surfaces of contact between a bridge-denture and the natural gum are filth-breeders, for it is impossible to reach such surfaces with the brush or to flush them out with water; and, no matter how close the joint may be made, particles of organic matter will insinuate themselves and there undergo decomposition.

As in the past all the laws of hygiene and sound mechanics have been repeatedly violated by conscienceless or incompetent operators, so in the future it is to be expected that they will be; and not only in bridge-work, but in other methods of dental prosthesis: for faults such as these the man, and not the system or method he misuses or misapplies, should be held responsible.

The fundamental principle underlying the construction of bridge-dentures is, that properly-placed and conditioned natural teeth or roots are far better fitted to sustain the force brought to bear upon an artificial denture than are contiguous alveolar surfaces. The practical experience of several years has fully demonstrated the truth of this fundamental idea. That being admitted, all the rest is detail, and bridge-work must be accepted as a legitimate and valuable method of dental prosthesis.

METALLIC FACINGS FOR CARIOUS CROWNS.

By WILBUR F. LITCH, M. D., D. D. S.

Metallic facings for carious crowns are made either of gold or platinum. Their purpose is the protection of gutta-percha, oxychloride, or oxyphosphate stoppings from attrition or chemical abrasion, thus supplementing those materials and rendering them comparatively durable in the mouth.

The first to introduce these additions to plastic stoppings was Dr. Bing of Paris, who for large crown-cavities employed a plate of pure gold, to the under surface of which loops of platinum wire were soldered, the facing thus prepared being pressed while warm into and upon a gutta-percha stopping placed in the carious cavity of the tooth for which the appliance was made, the edges of the facing being then burnished down to the tooth.

Prof. Charles J. Essig's modification of the plan consists in filling the carious cavity with wax up to the desired contour, taking an impression of the tooth thus prepared, and from this making dies and counter-dies, by the aid of which the facing can be accurately swaged, loops of platinum wire being then soldered to the under surface of the facing and imbedded in the gutta-percha with which the tooth is filled.[1]

In the simpler forms of cavities this plan is a good one, but in many compound cavities it is quite difficult, if not altogether impossible, to secure an accurate impression of all the margins; and without absolute accuracy the impression is worthless. Indeed, in any case the taking of an impression, making casts, dies, and counter-dies, unnecessarily complicate the making of metallic facings. Realizing their great value as a protection to plastic stoppings in very frail and badly-decayed molar and bicuspid teeth, the writer has endeavored to secure precise and simple processes for their preparation, so that they may be made and secured in position in less time and with less labor than is required for the introduction of the average gold stopping in the same class of cavities. The manipulative details by which these results may be attained will now be described.

Facings for Coronal Cavities.—For large crown cavities in the molar teeth of children metallic facings are especially useful. The tooth shown in Fig. 884 may be taken as representative of this class, it being assumed that caries has proceeded so far as to produce softening or disintegration of nearly all the dentine of the crown, leaving but little more than the

[1] See *Dental Cosmos*, June, 1877, p. 314.

enamel-walls standing. As in preparing cavities of this class for other forms of stopping, the first step is to break down the thin undermined enamel-edges of the coronal surface of the tooth until a strong, thick margin is obtained. The cavity being thus opened, the carious dentine may be removed in the usual manner and with the customary precautions as to exposure of the pulp, etc. As a rule, it is desirable that the facing should cover the entire coronal surface of the tooth; and in order to admit of this without interference with occlusion, it is necessary that a superficial portion of that surface should be removed, this being most readily accomplished by means of corundum wheels and disks of suitable size and shape. With copper- or tin-foil a pattern of the crown surface of the tooth should then be prepared, leaving it a little large at all margins.

FIG. 884.

Molar Tooth with large carious cavity.

As already stated, either platinum or gold may be employed in making the facing. Gold is more sightly, and is therefore generally to be preferred. It should be pure and have a thickness of about No. 28 standard gauge. From this material the facing is cut, the previously prepared pattern being used as a guide. The piece of gold, thus shaped and well annealed, is placed upon the tooth and with broad-pointed, serrated instruments is pressed into position; suitably-shaped burnishers may also be employed to secure perfect adaptation. Care should be taken to press the facing well up into the centre of the cavity, so that at this point a sufficient additional thickness may be given to the gold to secure durability in wear. After adaptation has thus been secured the edges of the facing are made flush with the walls of the tooth.

With a drill of suitable size two or more openings for retaining-pins are then made at convenient intervals through the facing. These are best made with a hand-drill and while the facing is in position upon the tooth. From platinum wire, No. 20 standard gauge, single-headed pins are then prepared, and passed through the openings made for them in the facing. If the size of the drill employed in making them corresponds to the size of the wire, the pins will fit tightly, which is very desirable. The pinheads should pass well up into the interior of the tooth, but not far enough to strike the floor of the cavity or to impinge upon a pulp-capping should there be one in position.

The pins, being suitably placed, are then to be soldered to the facing. For this purpose the facing, together with the pins, is removed from the tooth and placed upon the investment of marble-dust previously described and figured. (See Fig. 670, p. 843.) This suffices to sustain the pins in the proper position relative to the facing, especially if the pins have been made to fit tightly in the holes prepared for them. The investment also lessens the danger of fusing the facing in the soldering process.

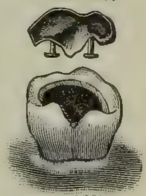
Twenty-carat gold should be employed as a solder. A little borax placed around the pins will facilitate its flow to the desired points. In the first soldering but a small amount should be used, the object being simply to secure the pins in the desired position. This being accomplished, the facing should be replaced upon the tooth to test its adapta-

tion. This proving satisfactory, the free ends of the pins are cut down to a level with the upper surface of the facing, which is then replaced upon the marble-dust and a sufficient quantity of gold flowed over its entire surface to give it the required thickness and rigidity. Centrally, the gold should be as thick as the nature of the occlusion will permit, while at the edges a much thinner surface may be made.

After this final soldering the occlusion is again tested. All very sharp and penetrating cusps upon antagonizing teeth should be partially cut down. A satisfactory occlusion being secured, the facing is ready for use in connection with the plastic filling.

As already stated, gutta-percha has been recommended and employed in connection with metallic facings. The writer, however, has not found it to be the most desirable material, and now but rarely uses it. In compound cavities it is not sufficiently stable, especially if loops instead of pins be employed, and in any form of cavity its expansion lifts the facing, often to a notable extent, from the surface of the tooth, thus interfering with the solidity of the facing and the durability of the stopping. A very much better material is oxyphosphate of zinc. This should be mixed to as thick a consistency as is compatible with perfect plasticity, a thick slab of glass and a broad, flexible spatula as described on p. 857 being used for the purpose. Both tooth and facing being previously thoroughly well dried, the oxyphosphate is by the aid of suitable instruments passed rapidly into the tooth until it is filled. A small amount is then placed around the pins of the facing, which is then pressed into position with broad-pointed, serrated instruments, one in each hand, the facing being steadied with the one hand, while with the other the entire circumference of the edge is pressed into close contact with the tooth. After allowing a few minutes for the cement to harden, the surplus may be removed from around the edges, and the facing be then polished by the same methods as would be employed with an ordinary gold filling, from which, when completed, it is difficult to distinguish it by a merely visual inspection. Fig. 885 shows the tooth with the facing ready to be cemented in position.

FIG. 885.



Facings for Proximal and Compound Cavities.—The making of facings for proximal and compound cavities in molars and bicuspids differs somewhat in detail from the processes just described. Fig. 886 represents an upper second bicuspid tooth with a large cavity in its distal surface. The method of preparing such a cavity for the placing of a metallic facing is almost precisely similar to that required for the introduction of a gold stopping by the aid of the matrix; thence it follows that if the cavity is not compound, it must be made so by breaking down or cutting through with suitable instruments, such as chisels, fissure-burrs, etc., that portion of the coronal surface which overhangs the proximal cavity. The slot thus made between the inner and outer cusps of the tooth need not be nearly so wide as that required for matrix-filling, neither is it necessary to weaken the walls of the tooth by retaining-grooves very deeply cut,

FIG. 886.

inasmuch as the oxyphosphate cement with which the tooth is to be filled adheres so closely to the walls of the cavity that it is amply secure against displacement even when the retaining-grooves are quite shallow. As the purpose of the slot is to allow of the passage into the interior of the cavity of the retaining-pins necessary to secure the facing in position, it may be made to correspond in width to the diameter of the pins made, while the length of the slot should be determined by the depth, transversely, of the carious cavity. In any case it is necessary to make the slot long enough to allow the pins to pass well up into the carious cavity, so that they may be securely grasped by the cement.

In addition to the formation of the slot a portion of the grinding surface of the tooth should be cut away, sufficient to permit a good thickness to be given to the crown-plate of the facing without interference with occlusion. This is a very important detail, and is best accomplished by means of corundum disks and points. In cutting away the enamel for the purpose indicated the surface upon which the crown-plate is to rest should be made as nearly as possible horizontal at a point just within the buccal and palatine edge, thence inclining inward toward the interior of the cavity. When the coronal surface is thus shaped the crown-plate can be made thickest at the centre, where strength is most needed.

When the tooth is in close contact with its fellow a separating file must be passed between them, and a space made sufficient to allow the passage of a piece of gold plate in thickness not less than No. 28 standard gauge. All very frail enamel edges should be removed, although a much greater tenuity to such edges is permissible than in the preparation of cavities for gold fillings. Carious dentine should be excavated with requisite care and by the usual methods.

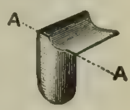
The facing for this form of cavity is made of pure gold of the thickness already indicated, No. 28 standard gauge. As securing economy in the use of this material, it is better to cut a pattern in copper-foil well annealed, making the pattern a little large in all its dimensions. It is desirable that the gold facing should extend beyond the margins of the cavity at all points. The cervical edge should pass up under the gum festoon; the buccal and palatine edges should be brought fully out of the interspace, so that the entire proximal wall of the tooth may be covered, while the crown-plate should be well depressed between the cusps, and cover the coronal surface to an extent sufficient to afford it a secure resting-place. The gold strip cut from the pattern will in general shape correspond to the outlines of the cavity, but will be a little larger.

In fitting to place, that end of the gold designed to form the proximal surface of the facing is passed up into the interspace far enough to extend beyond the cervical edge of the cavity and under the gum-tissue for about the thirty-second of an inch. With a thin burnisher the gold is steadied in this position by one hand, while with a broad serrated instrument held in the other the crown-plate is bent over upon the coronal surface of the tooth and as far as possible into the depression between the cusps. Without using a dangerous and painful amount of

force it is often difficult to produce the requisite depression at this point simply by the means indicated. In such cases the requisite curvature can be given by the clasp-benders figured on p. 835.

Thus rudely shaped, the facing will present the appearance seen in Fig. 887. It will often greatly facilitate the securing of adaptation and contour to make in the angles of the facing little slits, as seen at A, A: by the overlapping of the edges at these points redundant material is effectively disposed of. The cut edges are readily joined with solder when adaptation has been perfected. The greatest possible care must be taken to make the facing fit with perfect accuracy at all points. Pressure with serrated instruments will accomplish this for the coronal surface, and suitably-shaped burnishers for the proximal surface. Pure gold, of the thickness directed, is so soft and yielding that but comparatively little force is requisite.

FIG. 887.



The facing having been given the required shape, its buccal and palatine edges are made continuous with the buccal and palatine surfaces of the tooth.

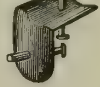
To secure the facing in position, two—and for very large cavities sometimes three—retaining-pins are requisite. One is passed through the crown-plate in a line with the long axis of the tooth, and the other through the proximal plate in such a position that the two pinheads will approach or meet each other at right angles.

The placing of the retaining-pins for facings of this class is that part of the processes for making them which gives the most trouble and requires the greatest delicacy of manipulation. If the pins are made too short, they will not be securely grasped by the cement; and if too long, they will strike against the walls of the cavity, and thus hold the facing away from the tooth. A little experience, however, will enable the operator to overcome difficulties and secure a uniformly satisfactory result.

The best plan is to make first the opening for the coronal retaining-pin. This should be made midway between the walls of the slot and as far from the proximal plate as practicable, the object being to bring the retaining-pin as close as possible to the inner wall of the cavity without absolutely touching it. With this pin the depth of the cavity can be accurately measured by passing the pin up until its head rests upon the cavity-floor. By then making a notch on the shaft of the pin at the point where it emerges from the opening in the crown-plate, a good guide will be secured for measuring the proper distance from the crown-plate at which to make in the proximal plate the opening for the proximal pin.

This opening must be in a direct line with the slot, and also be sufficiently far above the floor of the cavity to allow room for the edge of the pinhead when placed in position. In the average cavity the relative positions of the pins will be about as seen in Fig. 888, the coronal pin resting upon and being at right angles with the proximal pin, and the surplus ends of the pin-shafts protruding through their respective openings. If these openings have been made with a drill corresponding in size to the

FIG. 888.



platinum wire of which the pins are made, they will be tightly and securely held, and by simply imbedding the pins and under-surface of the facings in marble-dust each pin can be readily attached to the facing by means of a small piece of twenty-carat gold used as a solder.

The ends of the pins are then cut down flush with the surface of the facing and adaptation and occlusion tested. If the pinheads are found to strike slightly against the walls of the cavity, the latter may be cut away or the edge of the pinhead at fault may be made smaller, as circumstances may indicate. The exact point of difficulty may be determined by drying the cavity and coating the pinheads with black-lead, a mark being thus made upon the walls of the cavity at whatever point the pinheads touch. There must be left between the occluding tooth and the crown-plate space enough for the addition of at least its own thickness of gold in the final soldering process.

For this process the facing is again placed in marble-dust; a little borax is placed upon the crown-plate, and small pieces of twenty-carat gold are flowed over its surface until the requisite thickness is given. If slits have been made in the facing, their overlapping edges should be soldered at the same time. It is better, however, not to use borax at these points, as it is apt to cause the gold to flow through to the under surface of the facing, thus interfering with the fit. The coronal surface being soldered, the proximal plate is in its turn covered with a film of gold, which for close interspaces cannot be made very thick. Indeed, as this surface is not exposed to wear, great thickness is not requisite, unless it be to give contour.

After the final soldering adaptation and occlusion are again tested, and all the margins of the facing are bevelled to a very thin and perfectly smooth edge; this being specially requisite with the cervical edge which passes up under the gum. Before attaching the facing to the tooth its surface should be highly polished. Fig. 889 shows the completed facing.

FIG. 889.

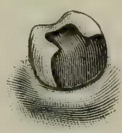
For proximal or compound cavities the use of gutta-percha stoppings in connection with metallic facings is ordinarily entirely inadmissible, as gutta-percha does not hold the pins with sufficient firmness to prevent displacement under the lateral strain produced during the act of mastication. For this reason an oxyphosphate stopping must always be employed in this class of operations.

The method of mixing the cement is the same as that already described in connection with crown facings. The cement should be very strong, set a little slowly, and be so mixed that it will be thick and yet perfectly plastic. The putty-like consistence which may be given to oxyphosphate preparations when employed in the ordinary manner as stoppings will not answer for use with facings, as these would be bent out of shape if forced into position upon so resisting a material.

All the appliances for mixing and other processes being at hand, the cavity and facing are first carefully dried. The cement is then mixed and the pins of the facing thoroughly covered, after which the cavity is filled and the facing pressed into position. All these details must be accomplished with swiftness and precision. In forcing the facing

into place it must always be kept under steady pressure with one hand while the other is engaged in perfecting the adaptation at various points. If this precaution is not observed, a rocking movement will be given to the facing, which will greatly endanger its security of anchorage. The usual plan is to press with a serrated instrument upon the crown-plate, at the same time using a thin burnisher to force the proximal plate against the tooth at all points, special attention being given to the cervical edge under the gum-margin, which should be burnished into the closest possible contact with the tooth-wall. Indeed, upon this closeness of contact at all margins of the facing will depend its permanency and artistic finish.

Fig. 890.



After the cement has hardened a final finish may be given to the edges by means of sandpaper, rubber disks, and polishing powders.

Fig. 890 shows a facing of this kind anchored in position.

Facing for a Molar Compound Cavity.—In Fig. 891 is represented a tooth in which not only the crown surface, but both the mesial and distal walls have been removed by caries. In Fig. 892 is seen the facing for the same, in which, instead of retaining-pins, a slender bar of platinum extending between and attached to the two proximal plates has been employed. This, in addition to serving admirably for anchorage purposes, has the further advantage that it acts as a brace to the facing, and thus gives it considerable rigidity. Fig. 893 shows the facing in position. In constructing a facing of this form it is better

Fig. 891.

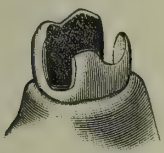
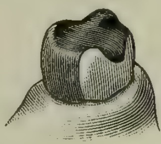


Fig. 892.

Fig. 893.



to make it in two sections, one for each side of the tooth, the crown-plates overlapping where they meet centrally. The overlap is readily united by solder, and it will be found much easier to form the facing in this way than to attempt to shape it from a single strip of gold.

As already stated, metallic facings are chiefly designed for use upon molar and bicuspid teeth of poor structure in which carious cavities of considerable size exist. Where amalgam would prove unsightly even if preservative, and where all other plastics would inevitably fail after brief wear, oxyphosphate stoppings protected by metallic facings give satisfactory and durable results. In large crown cavities they have an indefinite durability, and in the writer's practice large numbers of proximal facings have been in use for between three and four years, and still give no signs of failure. Indeed, while apparently much more exposed to displacement by mechanical forces and to erosion through chemical agencies than are crown facings, when the principles of construction are more closely examined it will be seen that there is between them less difference in these respects than would at first appear, because, like

a crown facing, a proximal facing rests, through its crown-plate, upon the coronal surface of the tooth to which it is attached, while the oxyphosphate stopping is as much protected under the one as under the other, unless the narrow margin at the gum-line be excepted. But here, too, the writer has always found the film of oxyphosphate intact when he has had occasion to remove the facing. Those who have had experience with crown work know that this is the case also when ferrules cemented with oxyphosphate are removed from around roots; indeed, the stability of all such operations is entirely dependent upon the fact that thus covered with gold or platinum the oxyphosphate preparations are entirely protected from destructive agencies.

As compared with gold fillings in frail teeth, the average durability and preservative power of the facing is probably the greater of the two, while for the larger cavities the saving of time and labor is very great. All the processes connected with the preparation and placing of facings are much less painful to the patient than are those incidental to the packing of large masses of cohesive gold; indeed, with care, the whole operation can be made absolutely painless.

A consideration of no small importauce is the fact that very many details connected with the making of facings are necessarily executed apart from the patient, thus affording him or her intervals of rest, and thereby very much diminishing the nervous strain not only for the patient, but for the operator.

While often a convenience, the use of the rubber dam is rarely absolutely essential to a successful result, even with facings for the lower teeth, as oozing from the gum-margin can be temporarily arrested by styptics, and, provided absorbent napkins of sufficient bulk are used, an expert operator can introduce the cement and press the facing into place so swiftly as to avoid all danger from salivary overflow.

Facings for Incisors.—In several instances the writer has had occasion to place facings upon badly-decayed incisors. Such facings are, however, much more troublesome to make than are those for bicuspids and molars. As a rule, they cannot be advantageously employed upon other than pulpless incisors, the retaining-pin in such cases being shaped like those used in mounting artificial crowns and extended into the pulp-canal. Without so deeply anchored a support an incisor facing brought fully to the cutting edge of the teeth is subjected to so much strain as to break away its attachments. If molar and bicuspid facings are properly constructed, this accident will very rarely happen. A cardinal principle in their construction is that in all cases the crown-plate of the facing should be so firmly and securely placed upon the coronal surface of the tooth that all the force applied in mastication will, through the crown-plate, fall upon and be resisted by, not the retaining-pins, but the tooth itself, the sole function of the retaining-pins being to hold the facing in contact with the tooth upon which it rests.

MOULDING AND CARVING PORCELAIN TEETH.

By WILLIAM R. HALL, D. D. S.

Early Methods.

As this article is intended for reference and practical utility, it is not necessary to give a complete history of the manufacture of porcelain teeth, especially as the early attempts are involved in some obscurity and the accounts given of them are unsatisfactory, no mention being made of the quality or quantity of the materials used. It is only from specimens of teeth still preserved that we can judge of their probable composition.

Some of the teeth brought from France by Dr. A. A. Plantou about the year 1820 were very imperfect representations of the natural organs, both in shape and color. The body of the tooth was made of a poor kind of porcelain, resembling Wedgewood ware, glazed over with a semi-transparent glass of a greenish or bluish color, with platinum pins to rivet to backings. These backings were previously soldered to gold wire, which passed around the adjoining natural teeth to hold them in place.

When we consider the beautiful glassware and porcelain that were made at that period, and also that rewards were offered by the French scientific societies for the best imitations of natural teeth, it seems remarkable that the French teeth were so rude and clumsy.

But little improvement was made in their appearance until the year 1825, when Mr. S. W. Stockton of Philadelphia and a few others made a much better composition, and produced teeth much more life-like in shade and shape. The teeth still had too much clay in them to stand the blowpipe without cracking; but after a few years this was remedied, so that with extra care a set of plain teeth could be soldered to a gold plate with a fair amount of success.

The teeth at this time were formed in moulds without backs; after being dried and turned out they were biscuited or half burnt, then coated with blue enamel and burnt in a muffle at a high heat; afterward they were painted at the neck with a yellow-colored glazing, which was fused at a lower heat: this painted neck, however, frequently changed color in soldering the teeth. When the moulding process was improved by the introduction of the double mould, the painting was abandoned, the enamel and body being placed in the mould at the same time and both being subjected to a heavy pressure before being burnt.

About the year 1840 a few dentists in Philadelphia began to make

what are now called carved block teeth. The single teeth made at this period were poorly adapted to fill up the irregular spaces in the natural gum. Whenever such irregularities occurred, it was impossible to fit the teeth together without leaving large spaces between them and the plate, which spaces only served to collect débris. To remedy this serious trouble, block teeth were made by moulding a mass of soft tooth-body on the gold plate. This was allowed to dry till it became solid, and was then trimmed to the proper height and fulness; the teeth were marked out and carved into shape with small knives; holes were drilled through the material back of each tooth for gold rivets, and the teeth were then enamelled, trimmed again, and burnt.

These blocks were riveted to the plate with gold wire rivets: it was not thought possible to solder such large masses of porcelain to the plate without cracking. But some years later the composition was so much improved by reducing the amount of clay that this became not only a possible, but the general, method of attachment for block teeth. The blocks were made thinner, and platinum pins were imbedded at the back for linings or stays.

For about twenty years the greater number of full dentures were made in this way; indeed, the method continued in general use until the advent of rubber made a revolution in the method of mounting teeth, by enabling the manufacturer to mould instead of carve blocks, thus lowering the cost and lessening the amount of work. Taking the country at large, rubber has become the almost universal base for artificial teeth, its durability and easy working qualities, together with its cheapness, recommending it to thousands who fail to see its defects.

It is computed by those whose opportunities for knowing are of the best that between seven and eight millions of artificial teeth are made in this country every year: fully nine-tenths of these are for rubber base, the remaining tenth for gold and silver plate-work.

Materials Used.

The materials used in the manufacture of porcelain teeth are *feldspar*, *silica*, *clays* of various kinds, including *kaolin*. The various compositions made of these materials are colored with *titanium oxide*, *platinum*, *cobalt*, *iron*, *gold*, and *tin*. These materials, when made into compositions for teeth, are divided into *tooth-bodies*, *coloring frits*, and *enamels*.

The *body* forms the bulk of the tooth: it represents the dentine of the natural tooth, and is composed of feldspar, silica, kaolin or other clays, and is colored with titanium oxide.

The *frits* are crude colors ground extremely fine, to which are added small quantities of feldspar and other fluxes, these being burned in a muffle, and kept powdered to use in making enamels.

Enamels are made of feldspar colored with small quantities of the different frits to imitate the natural colors of the human teeth and gums.

Qualities Required.—Certain qualities are essential in tooth-compositions, such as *translucency*, *plasticity*, *strength*, *stability*, and *natural color*. Good *heat-conducting quality* is also necessary.

The translucency is obtained from feldspar, which forms about four-

fifths of the bulk of the body: feldspar also acts in the nature of a flux, binding the other materials together. From its good heat-conducting property it is of great service in preventing teeth from cracking during the soldering process.

Silica forms the next largest proportion of the material in the body: it adds to its density and strength for masticatory purposes; being very infusible, it greatly assists in keeping the teeth in shape during the burning process.

Kaolin and other clays give that plastic quality to the body which enables the manufacturer to work and mould the mass to any shape needed. From its contracting quality while burning kaolin binds the other materials of the body closely together, thus giving the composition considerable strength.

This summary of the qualities of the various materials entering into tooth-compositions shows the necessity of a thorough and practical acquaintance with each and every mineral in its native or crude state—its working qualities and appearance before and after fusion. This knowledge is all-important, and when obtained it becomes comparatively easy to form good and valuable tooth-compositions. To assist those who wish to follow this study, a description of each substance is given, with the method of preparation best adapted to bring out its peculiar characteristics.

Feldspar.

Feldspar is a double silicate of aluminum and potassium, the orthoclase of mineralogy. It is found crystallized in rhombic prisms; its composition: silicic oxide, 66.50; aluminum oxide, 17.50; potash, 13; other bases, 3. Albite, a soda feldspar, and labradorite, a lime spar, are not used for tooth-compositions.

The best variety of potash spar comes from a range of hills in the vicinity of Wilmington, Del., and is justly celebrated for its excellent quality. When quarried it splits into plates of considerable size; it is of a yellowish color, is very free from quartz and mica, and when burnt in the furnace fuses into a transparent mass of a slightly blue tint, and if not overburnt keeps its shape without rounding at the corners, this being one of the tests of good spar.

There are several quarries in this vicinity which produce spar worthless for tooth-making, although it looks more beautiful and transparent in the crude state than the best variety, described in the preceding paragraph. This transparent variety when tested in the furnace fuses into an opaque white mass unsuitable for either enamel or body.

A pretty fair variety is quarried near Marcus Hook: it is rather rough-looking in the crude state, but fuses to a semi-transparent mass, and without the addition of a color makes a very good-looking white enamel. It can be used with advantage in the body of teeth, as it has more strength than the best quality of Wilmington spar. Spar from different parts of the same quarry differs in quality: the best is always selected for enamels. In making the selection small pieces, about half an inch in size, are broken off the fairest-looking specimens and fused in the

furnace to test the quality: the best of the crude pieces are then broken in small pieces with a steel hammer. The fine dust is thrown away, as it is likely to have in it particles of steel from the hammer: the coarse spar is then ground up in a large Wedgewood mortar without water. The powder during the process is frequently sifted through a No. 10 bolting-cloth sieve. It is kept dry in covered jars for future use.

In the preparation of spar for enamels the grinding must not be urged too far, as its transparency can be spoilt by grinding it too fine: a little experiment will prove this. Place on a slide covered with coarse silex a small piece of crude spar of the best quality; take also another piece from the same specimen and grind it very fine; fuse in the furnace, and when cold the difference in the appearance will demonstrate that the crystallization of spar must not be broken up too much, as when ground into such very small particles a loss of transparency is quite apparent: to preserve its beauty it must be ground to a certain fineness; beyond that opaqueness is the result.

It is the habit of manufacturers to calcine their spar by heating it red hot and throwing it into water while in this condition. This softens, or rather cracks, it into innumerable small pieces, much easier to powder; but the spar is frequently injured by the fire. The grinding is done in a large tub with a quartz bottom. A large quantity of water is added: when sufficiently ground the liquid is drawn off and allowed to settle, the water is siphoned, and the spar dried for use.

This plan is less laborious than dry grinding, but it prevents the nice separation of the proper-sized particles of the powder from those which are too fine; for in the water grinding the very finest float and are drawn off for use: in dry grinding this is prevented by frequent siftings during the process, and very little of the spar is ground too fine, the beauty of the spar being thus preserved.

Silica, Quartz.

Silicic oxide is a compound of silicon and oxygen. Under the name of quartz it is one of the ingredients of granite, which forms large mountain-ranges in various parts of the world. As silicates of aluminum, potassium, sodium, calcium, and magnesium it forms numerous rocks and minerals. Rock-crystal is pure silica crystallized in six-sided prisms. The finest and most beautiful varieties of quartz are the opals, agates, and amethysts.

A variety of quartz sufficiently pure for the making of artificial teeth is very abundant in hilly parts of this country, where it is found in large, irregular masses of white color, very compact, extremely hard, and very difficult to powder. A granular variety, composed of small crystals which readily fall apart when calcined, of a clear white color and translucent, is more useful to manufacturers. It is a very abundant mineral, and is found in almost every part of the world.

Silica is one of the most infusible of minerals, standing the most intense heat of the furnace without showing the slightest trace of fusion. If in fine powder, it slightly contracts in the fire, but keeps its shape perfectly. It is these qualities that make it so valuable in the plastic art.

Silica gives stability and firmness to the various kinds of ware that have to be subjected to the ordeal of the furnace: its infusibility stiffens and keeps the other materials in shape, and thus preserves the form given to it by the workman; it also adds to the hardness and density of the ware.

The tooth-maker incorporates it with spar and clay for these reasons: it is the main prop in tooth-body. A certain proportion is essential to raise the non-fusibility of the body in the furnace, to keep it from losing its shape while the enamel is allowed to fuse sufficiently to become transparent: after this it should be drawn from the furnace and allowed to cool slowly.

Quartz should be ground to an impalpable powder: its extreme divisibility materially aids in giving stability to the tooth-body and also adds considerable strength to the composition. As it is a very hard mineral, it requires a powerful grinding apparatus to reduce it to a fine powder: a grinding-mill turned by steam-power is usually employed, the finest part being floated off and dried for use.

Kaolin and other Clays.

All varieties of clay are aluminum silicates or hydro-silicates, and are frequently largely mixed with other substances; consequently the compositions vary according to the circumstances under which they are formed.

A number of precious stones are composed entirely of aluminum oxide, which when found crystallized of a red color is called the ruby; when blue, the sapphire; when green, the emerald; when yellow, the topaz; if dull and dark-colored and of granular crystallization, it forms the corundum from which corundum wheels for dental use are made; a still poorer kind is the well-known emery.

Kaolin and other clays are produced by the decomposition of granitic and feldspathic rocks, which, being granular, easily admit moisture, which, freezing, splits the rock, while the water, uniting with the carbonic acid of the air, dissolves out the potassium, leaving aluminum silicate more or less pure. In this way we get all varieties of clay, that from granitic rock having considerable loose quartz in the shape of sand and mica scales remaining in it; that from feldspar rock, particles of pure spar: the latter are the China clays, and by some are considered the best: the purest variety of clay comes from this source.

The clays are prepared for use by washing, which is readily done by mixing them with a large amount of water in a basin-shaped vessel: they must be thoroughly incorporated with the water, so that no lumps remain in them, sufficient time being allowed for the sand to settle before pouring off into another vessel. When the water becomes clear on top it is poured off; when dry, the mass should be carefully turned out and the bottom scraped free from any sand that remains clinging to it. If mica be one of the impurities, it is impossible to remove it entirely; such clay had better be rejected. When mica is mixed with clay, it can be seen in small scales all through it. Mica is a silicate of

magnesium, very infusible by itself and of no advantage in clays that are used for tooth-composition.

German clay is a very good article, having but few impurities in it, these being mostly sand: it is of a blue or black color, which, being of vegetable origin, burns out in the furnace and in no way injures the compositions into which it enters. This clay is imported from Europe to manufacture crucibles and assay-muffles, and also other articles that need an infusible silicate of aluminum.

When kaolin and other clays are pure they are very plastic and infusible, and as a consequence require a less quantity for the same purpose than when sand and other impurities are mixed with them. To get the full benefit of the plasticity of kaolin, it should be thoroughly incorporated with the other ingredients of the body, which can be done best by mixing them in the dry state and passing the composition through a No. 9 bolting-cloth sieve.

Formulas for Body.

The few formulas given below form standard bodies that can be relied upon to make good porcelain teeth; they have been well tested by use during many years. Other formulas could be given, but it is not thought necessary, as the manufacturer can vary them to suit any particular object he may have in view.

The materials should be thoroughly powdered in the dry state, weighed singly, and laid aside before mixing.

Bodies for Moulded Block Teeth.

I.		II.	
Kaolin	1 oz.	German clay	½ oz.
Silica	3 "	Silica	3 "
Feldspar	18 "	Feldspar	18 "
Titanium oxide	65 grs.	Titanium oxide	65 grs.
Starch, 10 grs. to each oz.		Starch, 10 grs. to each oz.	

It will be noticed that Formula No. 1 calls for twice as much kaolin as Formula No. 2 does of German clay, this difference being necessary in order to make up for the uncombined spar in the kaolin.

The best and most approved way to mix the materials is to place the titanium oxide and the starch in the mortar and grind them together first, without water; then add the kaolin; thirdly, the silica is added: these must be well ground together and sifted through a No. 9 bolting-cloth sieve; the spar is added last, and the whole composition passed through the sieve again, and kept in covered jars as stock for use.

The addition of starch to the body is the means of saving much time that used to be given to biscuit-baking, the heat of the moulds during the moulding process being just sufficient to turn the starch into mucilage, which when dried gives the teeth the firmness necessary to their safe handling and trimming before burning: it is entirely a vegetable substance, and burns out without injuring the body.

Bodies for Carved Blocks.

I.		II.	
Kaolin	1 oz.	German clay	½ oz.
Silica	3½ "	Silica	3½ "
Feldspar	14 "	Feldspar	14 "
Titanium oxide	40 grs.	Titanium oxide	40 grs.

No starch is used in body for carved blocks: the manipulations in forming the teeth are widely different, small knives being used to carve the teeth, and the body being dampened, which gives it sufficient toughness to work to advantage.

It will be understood that the above bodies are of medium color: if wanted darker or lighter colored, more or less of titanium oxide is used for the purpose. No iron or steel spatula should be used in mixing bodies or enamels: the smallest speck of iron will change the color of the composition. Bone or ivory mixers are used by careful workmen.

Attention is once more called to the kaolin. It ought to be of the purest variety, well washed and prepared. The loose sand kaolin sometimes contains is an adulteration, and lessens its plastic quality as well as the strength of the finished teeth.

Colors Used in Porcelain Teeth.

Artificial teeth are colored by various proportions of titanium oxide and preparations of platinum, gold, iron, and cobalt. The gum color is a combination of gold and tin: some manufacturers have used the oxides of uranium, manganese, and copper, but these latter colors have not proved to be very useful. The first named will give all the shades necessary for practical use if properly prepared.

Color is the first important requisite in artificial teeth: it is the color of the teeth that first strikes the eye of the observer; if it harmonizes with the complexion, the shape and position of the teeth are passed over with slight notice, but incongruous color is quickly observed by the eye and proclaims the artificial at the first glance.

Notwithstanding the great improvement in the manufacture of teeth in the last twenty years, much is still needed to make them in color a fac-simile of the natural organs: take, for instance, most of the rubber blocks now made. How poorly the enamels are blended! how harshly the bright yellow at the neck contrasts with the blue or gray at the cutting edge!—a contrast of color never seen in healthy natural teeth. On the contrary, the natural organs are of nearly one uniform tint from the gum to the cutting edge, with that pellucid softness in hue that is so agreeable to the eye.

If the manufacturer wishes to excel in his specialty, he should make efforts to obtain a thorough knowledge of colors and of the art of coloring, and particularly of the colors and hues best adapted to the four different temperaments: a nicely-educated eye is required to distinguish not only the primary and secondary colors, but also the shades produced by their mixture with feldspar. It must be remembered that the primary colors are too bright to be used singly; they must be subdued by the admixture of other colors to soften and tone them down.

Colors are divided into primary, secondary, and tertiary. The primary are *yellow*, *red*, and *blue*; the secondary, *green*, *orange*, *purple* or *violet*; the tertiary, *citron*, *russet*, and *olive*.

Green, made from a combination of yellow and blue, is as a color, *per se*, to be avoided in an enamel, but it is useful to mix with other colors.

Orange, a mixture of yellow and red, is a very desirable color if the yellow predominates.

Purple is a mixture of red and blue. The neutral colors gray and blue-gray are two of the most useful and the most difficult to produce of the proper tint.

Olive is a mixture of purple and green, and is useful to soften and darken the bright yellow of titanium oxide for deep-colored enamels: some pieces of impure titanium oxide produce an olive color.

In another paper in this volume will be found a description of the principal temperaments. Although more especially useful for practising dentists, a knowledge of this subject is very useful to the manufacturer as well. It will be only necessary to give in this paper, very briefly, some of the shades most suitable to the four principal temperaments (see p. 971), remembering that the natural teeth grow darker with age —the lymphatic changing from a white or opaque white to a dull brownish color; the sanguine from a light-yellow to a reddish-yellow; the nervous from a light-blue or gray to a dark grayish-blue; the bilious from a bright golden-yellow to a dark brownish-yellow.

Written descriptions of colors are necessarily very imperfect, as it is impossible to convey to the mind of a reader an exact idea of color by words. Color samples of enamels that can be seen from different points of view is the only correct way to obtain an accurate knowledge of the many tints and shades that are used.

A stock of sample teeth enamelled with the purest tints and shades should always be on hand for reference. Some of these are indispensable, such as teeth of a pure cobalt-blue, pure gray, pure yellow, pure green, and olive; also sample teeth enamelled with gold frit, gum-enamel, both red and rosy purple. Having these for contrast, enamels can be made with a certainty of getting pure tints and of duplicating favorite enamels.

Color Frits.

When more colors than one are used for enamels, they ought to be fritted, which is a convenient method of combining them in a homogeneous mass: it also effectually drives off any acid or combustible matter that may be in the crude materials. This plan has another advantage: the burnt frit can be ground exactly of the particular fineness required for mixing with spar without causing it to become opaque.

Great care and good judgment are needed in making metallic frits. All the materials should be pulverized extremely fine and be intimately mixed, for unless the oxides are thus minutely divided they lose their power of coloring, the finest ground oxides making the strongest

colors. A smooth mortar of hard Wedgewood is a necessity for grinding frits, and should always be kept for this particular use, and before being used for another color should be scoured out by grinding with quartz.

Frits are easily ruined by a too high or long-continued heat, as this reduces the oxides to the metallic state: they should be well luted in a clay crucible to exclude the air, and be brought to a heat sufficient to glaze them, after which they should be immediately cooled off.

The few formulas given below will be enough to show the combinations of oxides that are used to produce the ordinary colors and shades in artificial teeth. The number might be increased, but no advantage would result, as those given form the basis for all, and they can be varied to suit the idea of the manufacturer. It is also well known that owing to the difference in the manner of manipulating the materials, no two workmen with the same formula will bring out the same tint.

BLUE FRITS.

Platinum Frit, Blue.

Platinum (dissolved in aqua regia)	1 dwt.
Feldspar	1 oz.
Plate glass	20 grs.

Cobalt Frit, Azure Blue.

Smalt	60 grs.
Titanium oxide	6 "
Gold frit	60 "
Feldspar	1 oz.

Platinum Frit, Gray.

Platinum frit	30 grs.
Titanium oxide	10 "
Gold frit	100 "

Iron Frit, Gray.

Iron scale	4 grs.
Titanium oxide	1 "
Gold frit	60 "
Feldspar	1 oz.

Gold Frit, Reddish-brown.

Pure gold-foil	12 grs.
Plate glass	20 "
Feldspar	1 oz.

The metal for the platinum frit is dissolved in boiling nitro-muriatic acid, care being taken not to use more acid than is just sufficient to make a saturated solution. When cold the spar and glass are added and mixed with a glass rod, and placed in a clay crucible which has been previously washed inside with powdered quartz mixed with water. A cover must be closely fitted to the inner edges of the crucible, the joint being carefully closed or luted with clay and quartz, and burned as has been described.

The metal for the gold frit is dissolved in cold nitro-muriatic acid: with this exception it is treated in the same way as in the directions for the platinum frit.

GUM FRIT.

To make gum frit a gum oxide (purple of Cassius) must first be prepared. This is best made from Dr. E. Wildman's formula, which is as follows:[1]

[1] Other methods of making purple of Cassius will be found in the article on "Dental Metallurgy," in Vol. III.

To make Purple of Cassius.

Take of	Pure silver	432 grs.
"	gold	48 "
"	tin	36 "

First melt in a clean crucible the gold and silver, adding sufficient borax to fully cover the molten mass; then add the tin, and quickly pour the contents of the crucible into a Wedgewood or queensware basin containing clear cold water: the pouring should be in a thin stream and from a considerable height. The granulation of the metal will be favored if the water can be kept in rapid rotary motion during the pouring. The granulated metal is collected, remelted with borax, and poured as before. Several successive meltings and pourings are generally necessary before the metals become thoroughly mixed; this point is determined by the appearance of the alloy, which should be of a uniform color. When this result is reached the granulated alloy is collected and freed from any adhering borax, and is then placed in a Florence flask and subjected to the action of pure nitric acid diluted with from two to three parts of water: by this acid the silver in the alloy will be dissolved out and remain in solution in the form of silver nitrate. The application of a gentle heat through a sand-bath will greatly expedite the process. The precipitate which remains after the action of the acid ceases should be repeatedly washed with perfectly pure water, and again be treated with diluted nitric acid as before, repeating these processes until the acid bath when tested by muriatic acid or by common salt is found to be entirely free from silver, as indicated by the absence of the white precipitate of silver chloride. When this result is reached, the precipitate, purple of Cassius, which is an oxide of gold and tin in the form of a brown powder, is repeatedly washed in pure water to free it from all traces of acid, and is then carefully dried and kept in a tightly-closed bottle for use. All the materials employed in this process must be of the highest possible purity.

To make Gum Frit.

Take of	Purple of Cassius	16 grs.
	Feldspar	700 "
	Flux[1]	175 "

Mix the flux and feldspar together, and place the purple of Cassius, with four or five times its bulk of the mixture, in a Wedgewood mortar, and grind as fine as possible; then add from time to time, in small quantities, the remainder of the mixture of flux and feldspar, triturating as before. This process must be fully carried out, and the mass be reduced to the utmost degree of fineness. An expert workman should spend eight or ten hours in triturating two ounces. With the same material the most diverse results may be produced by greater or less care and attention.

To vitrify the powder, and thus form the gum frit, it is carefully packed in a clean crucible, the inside of which has been coated with very finely-powdered quartz mixed with water, care being taken to have this coating very thick over the entire inner surface: the purpose

[1] For formula for enamel flux, see p. 1007.

of this is to fill in the inequalities of the crucible and prevent the flux from adhering to its walls. Within the edge of the crucible a cover made from a fireclay slide should be neatly fitted, the joint being carefully closed with a mixture of finely-powdered quartz and kaolin.

The length of time required for full vitrification will not exceed twenty minutes if the fire is at the proper temperature: a bright-red heat is necessary. The intensity of the glow will guide the experienced operator. By too long an exposure to an intense flame the frit will be injured, if not rendered useless, this probably being due to the reduction of the gold to the metallic state.

When taken from the fire the crucible should be allowed to cool thoroughly. When opened the frit will be found contracted into a vitrified mass in the lower part of the crucible, and may be easily separated from its walls.

Gum Enamel.

Powdering the frit and mixing the proper quantity of feldspar with it require more than ordinary care: if the frit is ground too fine, its brilliancy is lost, and it becomes of a dull purple color when fused in the furnace. Or, conversely, if the particles of frit are too large, the enamel has a coarse or grainy appearance after fusion.

The frit is generally soft enough to crush under the pestle in a Wedgewood mortar, and while undergoing the grinding process should be frequently sifted through a No. 10 bolting-cloth sieve. If after testing the frit should prove of considerable coloring strength, it will have to be ground a little finer than the No. 10 sieve leaves it: this can be ascertained by trials of small quantities burnt in the furnace.

To arrive at the exact proportion of frit and feldspar that will produce the proper tint for gum enamel, several trials must be made, as follows:

No. 1.		*No. 2.*		*No. 3.*		*No. 4.*	
Frit	1 dwt.	Frit	1 dwt.	Frit	1 dwt.	Frit	1 dwt.
Feldspar . .	3 "	Feldspar . .	4 "	Feldspar . .	5 "	Feldspar . .	6 "

A little of each of the above trials should be enamelled on separate pieces of biscuited body, and the number of the trial marked on each, and memoranda be kept for reference. If after the trials are burnt No. 4 should prove too dark, make further trials, increasing the proportion of feldspar 1 dwt. at each trial to dilute the frit. When the proportion of frit and feldspar is finally ascertained, the balance of the frit is mixed with feldspar in accordance with the composition of that placed on the selected trial.

Blue and Gray Enamels.

Enamels are composed of pure spar alone or spar colored with portions of the various frits made for the purpose: no fluxes should be used in enamels; they give a glossy surface and decrease the beauty of good spar.

It must be remembered that the color of spar has considerable influ-

ence on the tint of enamel, some varieties having a blue tint, some a white or slightly yellow tint. A beautiful white enamel is made with the variety from Marcus Hook, and probably from other quarries. White enamel is used for persons of the lymphatic temperament, this type requiring little or no color: for older persons of the above temperament the spar should be colored with some of the gold frits, which give it a brownish or bronze color.

A brilliant blue of fritted cobalt, the smalt of commerce, is used for the lightest tints of azure-blue, but is seldom needed except when combined with platinum. As cobalt is a somewhat fugitive color, it requires some other color to hold it in place.

Platinum frit produces a blue color, somewhat gray in its tone, when mixed with good spar, but if the fusion is too long kept up it turns to a blue: it resists a very high heat without dissipating or being absorbed in the surrounding material; it is a strong and reliable coloring material. Enamel colored with this frit is of that peculiar tint of grayish-blue that is so becoming to the fair complexions of young people of the nervous and sanguino-nervous type of temperament: the lightest shades are the only ones needed to meet this type. To give the tooth a healthy or life-like look the neck should have a light shade of yellow enamel or body placed beneath the blue; if the yellow be too strong, it gives a greenish hue, which should always be avoided, as green and blue are discordant. For older persons of the above temperament the darker shades of blue should be toned down with the other colors, as the blue colors alone are too brilliant for any but the lightest shades of enamel.

Sponge platinum is sometimes used to make blue enamel, but is a more expensive preparation, and requires much heavy grinding to cut it sufficiently fine to make a good frit: it gives the same tints as metal platinum.

The scale oxide of iron makes a very pretty blue-gray color when combined with spar: the frit is intensely black, but when united with colorless spar produces a soft neutral shade of blue. For the medium colors it is a strong color, always reliable, and easily prepared. The scale is produced when iron is heated red hot in the open air. It should be fritted as in the recipe, especially when the darker shades are wanted.

Enamels of the same color frit are called shades, and are numbered from one up to ten or more, according to the degree of color, the number indicating the amount of color frit in grains to one ounce of spar, Platinum-Gray, No. 1, for instance, containing one grain of color frit to one ounce of spar; No. 2 containing two grains of the frit to the ounce; and so on increasing in the same ratio. A few examples from my book of formulas will indicate this more clearly:

Platinum-Gray, No. 1.		*Platinum-Blue, No. 1.*		*Iron-Gray, No. 4.*	
Plat.-gray frit	1 gr.	Plat.-blue frit	1 gr.	Iron-gray frit	4 grs.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 grs.	Starch	15 grs.	Starch	15 grs.
No. 2.		*No. 3.*		*No. 6.*	
Plat.-gray frit	2 grs.	Plat.-blue frit	3 grs.	Iron-gray frit	6 grs.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 grs.	Starch	15 grs.	Starch	15 grs.

Platinum-Gray, No. 4.		*Platinum-Blue, No. 5.*		*Iron-Gray, No. 8.*	
Plat.-gray frit	4 grs.	Plat.-blue frit	5 grs.	Iron-gray frit	8 grs.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 grs.	Starch	15 grs.	Starch	15 grs.

Yellow Enamels.

Titanium oxide, the rutile of mineralogists, is found in various parts of the United States, but the tooth-manufacturers are chiefly supplied from Chester county, Penna. It is found in the soil and picked up by the farmers when ploughing.

The pure titanium oxide colors spar a bright yellow: when used in body it produces a very good imitation of natural bone or dentine of the teeth; it is a fast color, not easily driven off by an excess of heat, and is readily reduced to fine powder in a Wedgewood mortar. Its composition varies considerably: the purest specimens are found in well-defined crystals, which produce, when powdered fine and mixed with spar, a bright yellow. Other specimens, not so well crystallized, have more or less iron, which darkens its brightness and produces various shades of olive-yellow. These impure pieces are very useful, when dark colors are wanted, to tone down the bright yellow of the pure oxide. A careful selection and separation of these different qualities is very essential, as many excellent shades can be made from them.

The pure oxide is too bright for the medium and darker yellow enamels, and has to be subdued with the addition of gold frit, which is a reddish-brown color. When mixed in proper proportions with the oxide it makes a beautiful soft yellow enamel which closely resembles the natural color of teeth of the bilious temperament. The titanium oxide can be still further darkened by adding small quantities of platinum and gum frits, producing smoke-colored enamels—a very useful shade for the practising dentist.

And just here a word of caution is necessary in regard to mixing yellow with blue. These two colors produce a green, which is an unsuitable color for teeth. A little gum oxide added will neutralize the green tint and make various neutral tints of brownish-yellow; indeed, there appears to be no end to the number of shades the combination of these three colors produces. The proportions of each color must be so exactly balanced that neither of them can be visible as a distinct color.

Uranium oxide makes a brilliant straw-yellow color not at all useful in coloring teeth.

The few formulas given below are for the purpose of showing the usual proportions of color and spar, but as no two batches of frit are of exactly the same strength, the mixer will have to use his judgment for the proper proportion of color to obtain the desired shade:

Gold-Yellow, No. 1.

Titanium, pure	1 gr.
Gold frit	2 grs.
Starch	15 "
Feldspar	1 oz.

Gold-Yellow, No. 2.

Titanium, pure	2	grs.
Gold frit	4	"
Starch	15	"
Feldspar	1	oz.

Gold-Yellow, No. 3.

Titanium, pure	3	grs.
Gold frit	6	"
Starch	15	"
Feldspar	1	oz.

Brown-Yellow, No. 1.

Titanium, pure	1	gr.
Platinum frit	1	"
Gum frit	4	grs.
Feldspar	1	oz.
Starch	15	grs.

Brown-Yellow, No. 2.

Titanium, pure	2	grs.
Platinum frit	2	"
Gum frit	8	"
Feldspar	1	oz.
Starch	15	grs.

Formulas for Continuous-Gum Work.

To make the lists of formulas more complete, a few for continuous-gum work are added. These have been selected from dental journals, and reproduced here to show the principle upon which such compositions are formulated.

On examination of Dr. Hunter's formulas it will be seen that considerable flux enters into them: this is for the purpose of lowering the fusing-point, that the teeth may not be injured by the frequent heatings that the work undergoes during the baking process. It will also be noticed that there is a difference in the fineness of the powders, some being prepared much finer than others. The finer act as a cement to bind the coarser particles together.

Continuous-Gum Formulas of Dr. Hunter.

Flux.	Quartz	8	oz.	Fuse in crucible to form glass; when cold reduce to powder.
	Calcined borax	4	"	
	Caustic potash	1	"	
Granulated Body.	Spar	3	oz.	Fuse in crucible, and powder to pass through No. 50 wire sieve.
	Quartz	1½	"	
	Kaolin	½	"	
Body.	Flux, as above	1	oz.	Grind the first two articles very fine, then add granulated body, which is mixed with the fine without grinding.
	Asbestos	2	"	
	Granulated body	1½	"	
Gum Enamel.	Flux, as above	1	oz.	Grind very fine and semi-fuse in crucible; powder coarsely for use.
	Fused spar	1	"	
	English rose-red	40	grs.	

Formulas of Dr. D. D. Smith.

Granulated Body.	Quartz	20	grs.	Grind fine and fuse on slide in furnace; powder coarsely for use.
	Spar	24	"	
	Caustic potash	1	"	
	Titanium	2 grs.–1	oz.	
Flux.	Quartz, very fine	18	dwts.	Fuse same as above, and grind very fine.
	Spar	10	"	
	Glass of borax	2	"	
	Cryolite	1	dwt.	
	Caustic potash	10	grs.	
	Titanium	1½ grs.–1	oz.	
Gum Enamel.	Gum frit (of S. S. White)	4½	dwts.	Fuse and grind for use.
	Flux without titanium	16	"	
	Granulated body	11	"	
	Cryolite	7	"	

Dr. Moffit's Formula for Continuous-Gum Body.

Body.	Spar	12 oz.	Grind coarsely.
	Quartz	$4\frac{1}{2}$ "	
	Bohemian glass	60 grs.	
	French china	35 "	
	German clay	2 dwts.	

No gum-enamel formula came with this. Dr. Smith's formula for gum enamel will do for the above, minus the cryolite.

Dr. John Allen's First Formulas, now Out of Use.

Body.	Quartz	2 parts.	*Gum Enamel.*	Spar	$1\frac{1}{2}$ oz.
	Flint glass	1 "		White glass	1 "
	Borax	1 "		Oxide of gold	$1\frac{1}{2}$ grs.
	Wedgewood	$1\frac{1}{2}$ "			
	Asbestos	2 oz.			
	Spar	2 "			
	Kaolin	1 "			

Shapes and Sizes of Teeth.

The study of the basal temperaments should claim the earnest attention of the manufacturer of artificial teeth: it is only from this study that a correct idea of the harmony of temperament with the shape and color of human teeth can be obtained.

The teeth of each temperament have a characteristic shape and color, and are just as distinctive of temperament as the color of the eyes and hair or shape of the body and contour of the face. Those of the basal temperaments afford the broadest and most familiar types, and are well defined and easily recognized: it is from these indications that all artificial teeth should be modelled and colored, for they are the foundation types. The laws governing their combination should be well studied and thoroughly fixed in the mind of the manufacturer, so that he may be duly prepared to make suitable forms and colors that will harmonize with each temperament. As a step in this direction the following tables give a proximate idea of the relation of shape and color of teeth to each basal temperament:

Bilious Temperament.

Color:
 Golden yellow.
Shape:
 Flat face, large and angular.

Sanguine Temperament.

Color:
 Soft yellow.
Shape:
 Round face and bold.

Nervous Temperament.

Color:
 Transparent blue or gray.
Shape:
 Graceful, semi-round face.

Lymphatic Temperament.

Color:
 Opaque white.
Shape:
 Spheroidal, broad, and rather short.

The dual temperaments are combinations or modifications of the above.

The shapes and sizes, as well as the color, of natural teeth are supposed in a great measure to indicate the four principal temperaments—thus individuals of the bilious temperament have large and rather long, flat-faced teeth with square corners and broad necks; those of the sanguine temperament have teeth smaller in size, with convex or round face

and proportionate necks; those of the nervous temperament have rather long and slender teeth, with semi-round or convex face and narrow necks, longitudinal indentations, and graceful outlines; while persons of the lymphatic temperament have short, broad teeth, very convex face of a spheroidal shape, the very opposite of the graceful nervous type.

The above description gives a general idea of size and shape as derived from writers on this subject, but is too vague and indefinite to be of much service to the manufacturer of artificial teeth. He needs a more accurate and practical guide—something he can measure and gauge with compass and rule. It was this want of something more definite that led the writer some twenty-five years ago to collect large numbers of human teeth for the purpose of ascertaining as nearly as possible the correct outlines, exact sizes, and other characteristics of the natural organs, with the reasonable expectation that some better order or system could be produced that would more closely resemble nature than the old plan of one unvarying shape of different sizes, which was the rule before and up to that time.

In carrying out the above ideas it became necessary, in the beginning, to confine the examination to the crowns of the incisors and cuspids of the upper and lower jaws, these being the most important, as distinctive of shape and temperament.

In assorting the teeth and distributing them into groups it soon became apparent that there were three distinct and characteristic shapes that were so dissimilar as to demand classification; consequently, they were divided into three classes only, simply as a matter of convenience at the time, but afterward this was found so useful that it was continued. These three classes contain, practically, all the desirable shapes for manufacturing purposes.

In the first class were found round- or convex-faced teeth, the convexity being the greatest from the proximate surfaces, the lesser convexity from neck to cutting edge of the teeth; the necks were generally broad.

The second class consisted of the semi-round-faced teeth, whose convexity was less than that of the first class, with narrower necks and more graceful outlines.

The third class represented the decidedly flat-faced and angular variety—sharp corners, square form, with rugged outlines.

In each class were teeth of different widths and lengths of the crowns, with narrow and broad necks, necessitating a further division, as will be seen in the enumeration of sizes. The maximum and minimum widths and lengths of the crowns were then carefully measured and noted in forty-eighths of an inch: the convexity of the face and outlines of the proximal surfaces were taken in plaster, and working models were made from them for future use.

In the enumeration of sizes given below the forty-eighth of an inch was adopted for the difference in the sizes of the natural teeth measured, this fractional part of an inch being easily discerned by the eye and being found most convenient for general use.

The largest superior centrals measured twenty forty-eighths of an inch in width at the cutting edge; the length of crown from cutting

edge to neck was twenty-four forty-eighths of an inch; the width of necks varied from sixteen to eighteen forty-eighths of an inch.

The smallest superior centrals at the cutting edge measured fourteen forty-eighths in width and sixteen forty-eighths in length of crown; the necks were from ten to twelve forty-eighths of an inch in width.

Among the natural teeth examined were sixteen sets of upper front teeth, each set enclosed in a small bottle filled with alcohol, as imported from Europe for use as pivot teeth: these sets were very well matched, and were of great advantage in ascertaining the relative sizes in each set. The superior laterals were generally two sizes smaller in width and length than the centrals of the same set. The superior cuspids were about one size narrower than the centrals of the same set, but of the same relative length. The bicuspids were four sizes narrower than the centrals of the set, and two sizes shorter in length. The molars varied from eighteen to twenty-two forty-eighths of an inch in width, and from fourteen to eighteen forty-eighths in length: the outer or buccal cusps of the bicuspids and molars were longer than the palatal.

The assortment of lower teeth obtained was not so large, but enough were examined to show two distinct classes—the round- and flat-faced: the round had broad necks, the flat had narrow necks. The width of the lower centrals varied from seven to ten forty-eighths of an inch, the length from sixteen to twenty forty-eighths. The lower laterals were two sizes wider, and of the same length as the centrals. The lower cuspids were two sizes wider than the laterals, and one size longer. The bicuspids and molars were generally of the same width and length as the corresponding upper teeth, but the outer cusps were lower than the inner.

From the data above given it was comparatively easy to classify or formulate a system of shapes and sizes with sufficient correctness to essentially comply with the requirements needed by the practising dentist.

This system, with its details as above briefly described, may seem a very formidable undertaking for the manufacturer, but when thoroughly understood will be found the most simple and practical that can be given, so as to embody what is absolutely necessary to successfully carry out the general requirements continually coming from the dental profession. It is admitted by the best informed that a business is not successful unless *system, talents, knowledge,* and *energy* enter into all its details: the last three are frequently thrown away when not brought under control by a complete system applied to every department of the business; and more especially in the manufacture of teeth is some system urgently needed that will produce the identical shapes and sizes that will be an approximation to the temperament and physiognomy of different individuals, the want of which is so apparent in artificial teeth as now manufactured.

To give a better illustration of the system above recommended a table of widths of teeth are here given, as derived from the measurements of natural teeth before alluded to:

Widths for all Classes of Teeth.

Centrals	No. 1, $\frac{18}{48}$;	No. 2, $\frac{17}{48}$;	No. 3, $\frac{16}{48}$;	No. 4, $\frac{15}{48}$;	No. 5, $\frac{14}{48}$.
Laterals	" $\frac{16}{48}$;	" $\frac{15}{48}$;	" $\frac{14}{48}$;	" $\frac{13}{48}$;	" $\frac{12}{48}$.
Canines	" $\frac{17}{48}$;	" $\frac{16}{48}$;	" $\frac{15}{48}$;	" $\frac{14}{48}$;	" $\frac{13}{48}$.
Bicuspids	" $\frac{14}{48}$;	" $\frac{13}{48}$;	" $\frac{12}{48}$.		
Molars	" $\frac{22}{48}$;	" $\frac{20}{48}$;	" $\frac{18}{48}$.		

Length of Crowns.

Length of the longest, $\frac{24}{48}$; the medium, $\frac{20}{48}$; shortest, $\frac{16}{48}$.

The widths in the above table are sufficient in range to meet general requirements, and apply to all the three classes, both broad and narrow necks, as well as the three different lengths. The No. 1 centrals, laterals, cuspids, bicuspids, and molars form one set; the No. 2, a narrower set; the No. 3, still narrower; and so on to the end.

Below is a list of all the sets needed to complete the scheme as proposed in the foregoing remarks:

FIRST CLASS: *Round Face, with Broad Necks.*

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Narrow Necks.

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

These thirty sets constitute all of the first class.

SECOND CLASS: *Semi-round Face, with Broad Necks.*

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Narrow Necks.

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Thirty more sets, constituting all of the second class.

THIRD CLASS: *Flat Face, Broad Necks.*

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Narrow Necks.

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

These thirty additional sets complete the list of ninety sets in all, making a fair assortment of plain teeth for plate or rubber base.

It will be seen that the bicuspids and molars in the above list are the same length as the incisors: this is contrary to the usual custom of manufacturers, as they make sets with the back teeth shorter than the

front; but the dentist finds from practice that the majority of cases for full sets require teeth of the same length all round the arch, except the last or second molars.

Plain single teeth, or teeth without artificial gums, have been selected as the best form of teeth to exemplify the system recommended in the preceding pages. When this system is applied to full sets of sectional blocks for rubber base, it will be necessary to slightly shorten the bicuspids and molars, and let the artificial gum fill up the deficiency in length of the teeth. This shortening of the crowns of the bicuspids and molars should not be to the same extent that we usually see in gum blocks, as most of these are so short that the necessary grinding of the cusps to fit them to the lower teeth leaves the tooth about half the length it ought to be, and brings the artificial gum down too much into view.

To explain my meaning more fully: it must be remembered that sectional-block teeth are intended for persons who have lost all their teeth and their alveoli, thus leaving a large space to be filled. Sometimes we see patients who are blessed with teeth of unusually dense dentine which last them to old age: when this latter class arrive at middle age they show considerable recession of the gum, exposing the entire crown and a portion of the neck. It is this characteristic of age that should be imitated in sectional blocks. A youthful set of small, even teeth would look very unnatural and out of harmony with the physiognomy at this age.

What are needed for this time of life are teeth of nearly the same length, the cutting edges rather uneven, canines a little darker in color than the incisors, and the molars still darker—an ideal set for middle age.

Contrary to this, manufacturers work on the principle that all artificial teeth should be made to look as youthful and beautiful as possible. This is a great mistake: it is rarely that a perfectly even and youthful set of block teeth is needed, more especially for patients living in the populous cities: almost all of this class, appreciating the value of their own natural organs, try to save them as long as possible, and it is only when they give out entirely in middle age or later in life that they procure an artificial set.

There are a great many difficulties to overcome in making moulded teeth to resemble the natural organs. The mould must be so shaped as to deliver the block without breaking, and afterward be trimmed by file and knife to bring out the proper outlines; but by skilful cutting of the mould all the peculiar characteristics of each class can be blocked out and perfected in the after-trimming before the burning process.

Such irregularities as the lapping of teeth one over the other can never be so moulded so as to present a natural appearance, and attempts to produce this result usually end in dismal failures; but the cutting edges can be moulded unevenly and look very well. Irregularities to look natural must harmonize with the peculiarities of each individual patient: what suits one is very rarely becoming to any other. No rules can be laid down that can be carried out successfully: the attempt to make two or three styles of artificial irregularities for all classes of persons usually results in monstrosities.

Position of Teeth.

After shape or size, position or inclination naturally follows as the next elementary principle belonging to the artistic part of tooth-manufacture. Each and every position has a positive value in individual expression, either enhancing its beauty or producing deformity of the mouth. Nothing about the artificial denture so changes the expression of the mouth as the position of the teeth: it is the skilful management in placing them in the exact and proper position which they ought to occupy that results in producing that perfect harmony of the teeth with the profile of the face which is so pleasing to the patient and satisfactory to the operator.

The position or inclination of the teeth is a most important consideration in their construction, and should not be passed over without thorough and exhaustive investigation; and this cannot be too strongly urged on the attention of the manufacturer. Its value has been strangely overlooked or else studied with very little success, for we see in the bulk of artificial teeth at the manufactories that very little effort has apparently been made in this particular direction. It is in this part of the art that improvement is urgently needed in the construction of rubber blocks and gum teeth.

The term "position," as used here, refers to the inclination of the front teeth from the perpendicular in two directions—namely, the forward and the backward, the degree of inclination corresponding to the conformation of the face.

In the human subject the teeth assume these positions from the controlling influence of osseous development in the upper and lower maxillary bones, continuing from extreme youth to adult age, completing the facial type or individuality in the profile of the face. The inclination of the teeth gives a special character or expression to the mouth, supporting the lips and helping to form the curves and lines in the varying movements of the muscles surrounding the mouth, and is one of the features of the physiognomy that should be studied by the manufacturer with the greatest care. The form of the mouth is, as indicative of character, quite equal in importance to any other portion of the face: examples of this can be seen in the mild and timid look of the retreating chin, the resolute and commanding aspect of the perpendicular cast of face, contrasted with the animal type of the protruding teeth and jaw.

Among the inhabitants of a large city we see various types of facial conformation, a profile view of which will show how important it is to have some practical knowledge of the facial angle, or, better still, the principles of ethnology as shown in the various national types of mankind. Drs. Nott and Gliddon's work on *The Indigenous Races of the Earth* is a very interesting and instructive book, and could be studied with profit in this connection. A few words, giving a general description of facial conformation, will be sufficient to convince the reader of the importance of further knowledge on this interesting subject.

There are three distinct types or classes of facial conformation found

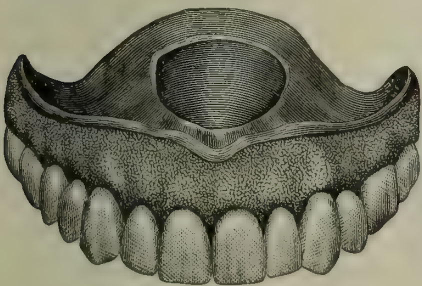
in this country. The first class, the most important and by far the most numerous, is the Anglo-Saxon type, descendants from the early settlers of this country, by some authors called Anglo-American, the contour of the head being oval, with slightly sloping forehead, rather long nose, both maxillary bones the same length, and teeth standing perpendicular or nearly so, giving a firm expression to the mouth: this is the general conformation of the unmixed native population at the present day.

The second class differs from the above in having a retreating chin. This can hardly be called a national type, and yet is quite often met with: this conformation may frequently be seen among a certain class of Italians, but is not a national characteristic. It might be called sporadic, if we may use the term in this connection: it is not confined to any particular nationality, but is scattered here and there. It is purely effeminate in character, showing poor development of the lower maxillary bone, this causing the upper incisors to incline backward to meet the lower teeth. Blocks suitable for cases of this kind of articulation should be made with the teeth inclining a trifle back of the perpendicular in the upper jaw, and the incisors of the lower jaw inclining forward to pass just inside of the upper teeth.

The third type is more numerous than the second, and the conformations of the facial outlines are very different. Both upper and lower jaws are very prominent, thus causing the teeth to protrude at a sharp angle at the cutting edges. This prognathous type is found chiefly among a certain class of Celtic origin. When this elongation of the jaws is excessive it culminates in the Ethiopian type. In the teeth of this facial type both jaws incline forward at an acute angle of from 70° to 80°, the plane or base line being the cutting edges of the teeth.

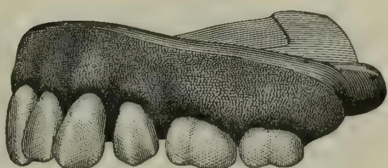
The three facial types above represented are of individuals with full natural dentures: they are given to illustrate the general positions or inclinations that should be observed by the manufacturer of blocks and gum teeth. If teeth were manufactured in accordance with these

Fig. 894.



First Position, front view.

Fig. 895.



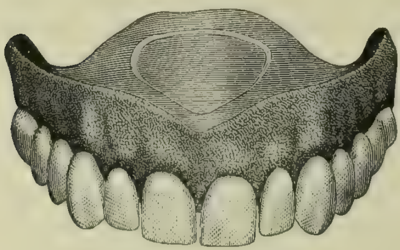
First Position, side view.

three angles of inclination, all the intermediate ones could be made by judicious grinding, and thus a great variety of expression produced that would harmonize with the ever-varying facial conformations that are continually presented to the practitioner of dentistry.

For a better understanding of the above typical classes they are here arranged into three classes or positions, and each position numbered and illustrated by a wood-cut which will show the angle of inclination for each class.

Figs. 894 and 895 represent a duplicate set of teeth made for a gentleman of sanguine temperament. It will be seen that the teeth are closely set together, and are of the round and broad-necked variety, indicative of solidity and strength. Spaces were left between the cuspids and first bicuspid, and between the bicuspid and molar, to please the fancy of the patient. It will be noticed also that the laterals are a trifle shorter than the centrals: this was for the purpose of breaking up the uniformity of closely-set teeth, and yet still preserve the strength of character which this grouping is intended to represent. The size and form of the teeth for this position vary from the smallest to the largest, and include

Fig. 896.



Second Position, front view.

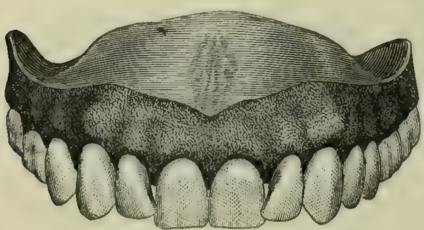
Fig. 897.

Second Position, side view.

the flat-faced, round, and semi-round-faced, in accordance with the different temperamental indications and the sizes of dentures.

Figs. 896 and 897 are views of a temporary set of teeth made for a lady with a retreating chin. The side view shows how the centrals were drawn inward to harmonize with the profile of the face. If all of the front teeth had been inclined backward in the same degree, it would have given the teeth a lugubrious look. The side view shows the laterals inclining to the front, with mesial corners shorter than the distal. The cuspids are observed to be nearly perpendicular, only slightly inclining to the front, which relieves the teeth from the hooked look they otherwise would have. Small spaces are left between the teeth to give them a lighter and more gentle expression. The inclination of the central incisor teeth, as seen in the side view, shows an obtuse angle of 100°, taking the masticating surfaces of the teeth as a base line: the gum above is seen in advance of the teeth below. For teeth of this position the medium and smaller sizes are suitable, and the form should be of the nervous and sanguine type.

Fig. 898.



Third Position, front view.

Figs. 898 and 899 show the forward inclination for the third position. The views are of a set of plain teeth mounted on celluloid, constructed for a patient with a very prominent chin: the lower incisors and cuspids were the only natural teeth remaining in either jaw. In this case the artificial upper teeth had to incline forward very much to meet the lower incisors. It will be seen that the positions of the teeth are peculiar, but are such as are frequently observed in natural teeth. The front view shows the centrals squarely set together, the laterals inclining forward, so as to slightly overlap the centrals, the cuspids inclining rather less: the unevenness of the cutting edges of the teeth gives a very natural look to this grouping. The side view shows the angle of inclination of the front teeth to be 70°, with the bicuspids and molars standing nearly perpendicular. The gum above is seen sloping backward to give prominence to the incisors, which is the principal characteristic of the third position.

FIG. 899.

Third Position, side view.

Cases which need this arrangement of the teeth are very numerous in dental practice. The loss of the upper teeth and the consequent absorption of the alveolar ridge cause a permanent contraction of the muscles of the upper lip, which necessitates the arrangement in question. The manufacturers have failed thus far in giving us blocks with the required angle of inclination for this kind of cases: it is to be hoped that this long-felt want may soon be filled.

The above observations on the three general positions or inclinations for the manufacture of gum teeth and blocks are deemed sufficient to show the importance of this much-neglected part of the art, for no beauty of color or form will compensate for the want of the proper curve or inclination of the teeth.

Brass Moulds for Porcelain Teeth.

We now come to that part of tooth-manufacture requiring peculiar talents and skilful hands—the imitation of the beautiful contours and outlines of the natural teeth.

A word of caution is needed here. No artisan can expect to become an expert in this department unless he has a talent for forms of the beautiful in sculpture or some ability in modelling in clay or in carving small objects in wood: if the talent exists in the individual, it can be developed by study and practice, not otherwise.

Mould-making includes the design, making the plaster pattern, casting it in hard brass, cutting and finishing the mould. These several parts require a diversity of talent rarely existing in perfection in one individual, and they are therefore generally divided by manufacturers among different employés.

The matrix or *mould* must be made of hard brass, as the ordinary brass is entirely too soft to withstand the wear and heavy pressure to which it is subjected in the process of moulding teeth. To form a com-

plete assortment of the various shapes and sizes of teeth, so as to fill the present requirements of prosthetic dentistry, requires a stock of between four and five hundred moulds, including duplicates of favorite sizes, so that it is not only a most costly part of the apparatus of the manufactory, but one most difficult to perfect.

The design is the first or original set of teeth made of wax or plaster from which the plaster mould is taken. It is almost needless to say that the designer and pattern-maker should have a thorough anatomical knowledge of the several classes of human teeth, and of their shapes and positions; he must also have skill to carve correct imitations of them in plaster according to the profile and contours of the natural organs, and an artistic eye to arrange them in their proper positions for the dental arch.

To facilitate the making of the design, face-blanks of the teeth are first prepared. These are made of ivory, bone, or plaster: plaster is generally used, on account of its easy-working qualities. These are moulded from plain-teeth moulds, somewhat larger than is needed for the set to be made, to allow a sufficient surplus of material for carving to the proper size and shape; which sizes and shapes should be in accordance with the tables on p. 974. The blanks give only the outlines and face profile of the teeth, the inner or lingual portion being cut away to enable the blanks to be set at any angle desired.

The carving is done with a small penknife blade, a half-round file, and a small spoon-shaped scraper. After the face-blanks are correctly formed they should receive a thick coat of shellac varnish to protect them from injury.

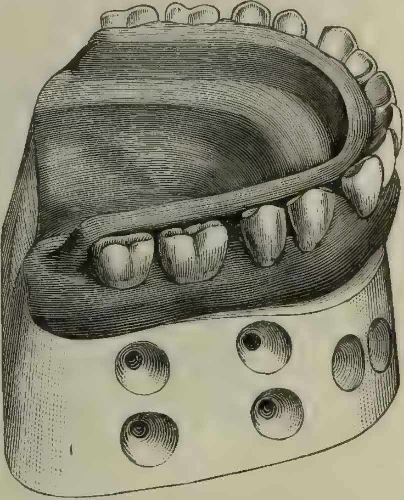
It is a frequent practice among manufacturers to use plaster copies of old moulds, altering them somewhat to transform them into new ones. No poorer plan could be thought of, as it is next to impossible to so obliterate the old design that some objectionable part will not show in the new: an entirely new design is always the best, more especially for the front blocks.

A cast must be prepared to model the design on. A number of these should be on hand, varying in size according to the width of the teeth used. For illustration, we will use a cast of a medium-sized edentulous jaw of good and regular form: this is enlarged an eighth of its width and depth by cutting through the centre with a saw along the mesial line back to the palate, then across the cast just back of where the eye-teeth should be; the four pieces are then placed together, so as to make the cast an eighth larger each way; they are then fastened with small pieces of wax to hold them in position until the spaces are filled with freshly-mixed plaster to make it a solid cast again.

On this cast a plate of paraffin wax, not less than an eighth of an inch in thickness, is moulded: the teeth blanks are arranged on this base according to a previously conceived design, which must be well planned and fully matured in the mind before beginning to carry it out. Assuming that the desire is to make a mould for a set of upper blocks with a perpendicular bite, a set of blanks, as previously described, is selected of the semi-round-faced class and medium size: these are fastened to the paraffin base with a little yellow beeswax, which will hold

them in any position desired; they are so arranged as to drop perpendicularly from the arch. A small space must be left between the teeth of each section, and a larger one between each of the sections. The grouping is as follows (see Fig. 900):

Fig. 900.



Tooth-blanks arranged on cast.

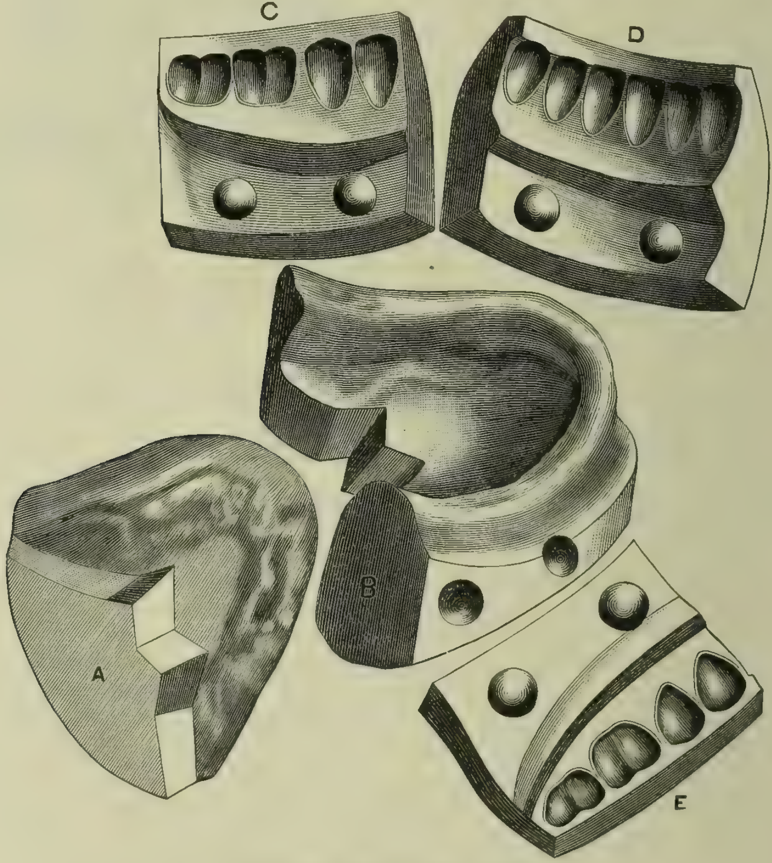
The centrals are placed nearly squarely together, the laterals sloping slightly toward the mesial line; the cuspids are placed perpendicularly, and are made more prominent and a trifle longer: the bicuspids and molars should be placed in nearly a straight line from the cuspids to the end of the cast, and should not be curved: this arrangement suits the large majority of cases.

After the arrangement is completed paraffin wax is melted on the labial side to form the gum, and is carved with a small knife into the proper shape. If the carving is rough, the flame of a small alcohol lamp passing rapidly over it will smooth it again. Paraffin wax instead of beeswax is used, as it is firmer and more easily carved. The lingual or inner side is then backed with paraffin wax and trimmed to the proper thickness for the blocks: the masticating surface of the bicuspids and molars is left plain, as is also the recess for the pins.

A wall of plaster about one-fourth of an inch in thickness is now run on the outside of the blanks and modelling cast from one extremity to the other: after becoming hard it is trimmed even with the inside of the cutting edges of the tooth-blanks, varnished, and oiled; then an inside wall is made of plaster reaching as high as the outside one. After becoming hard the inside wall is removed in one piece, and the outside one is cut into six pieces with a thin saw-blade fastened in a hand-frame —the cuts being made between the centrals, between the cuspids and bicuspids, and between the bicuspids and molars; the pieces or sections are then separated from the cast. If the separation between the teeth where the cut is made is wide enough, the blanks will not be disturbed. Both inside and outside walls are then carefully trimmed and varnished and laid aside to dry. The blanks are removed from the cast, from which all small pieces of wax and plaster are cleaned, and both walls are varnished. Fig. 901 shows the walls for a lower set of plaster blocks. The walls are replaced on the cast and secured in position with twine or wire; after being oiled plaster is run in between them and allowed to set hard before removal; if the plaster has run into all interspaces between the walls, a continuous set of plaster blocks will be produced. These with a thin saw are cut into six sections, as represented in Fig. 902, the six front teeth in two sections of three teeth each, the first and second bicuspids of each side in two other sections; the molars are divided in the same

way. These are the plaster blocks; they require trimming on the inside, and the cutting of a recess for the pins and the carving of the masticating surface of the bicuspids and molars to represent human teeth, as seen in Fig. 902. Care must be taken to trim the ends of the blocks so that they will taper enough to deliver from the plaster mould: if not properly bevelled the pattern blocks will be ruined in removing them. The

FIG. 901.



View of the Walls and Cast, separated.

blocks must receive two or three coats of shellac varnish, and be well dried before they are used.

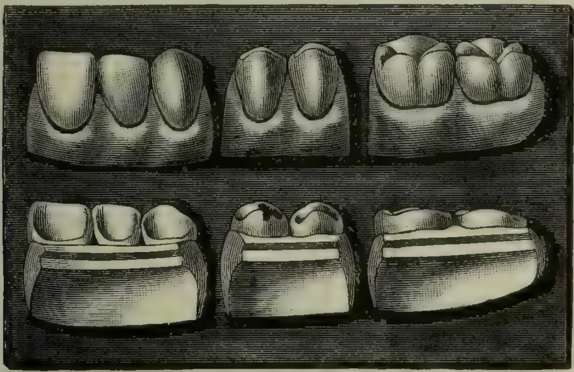
Manufacturers have different methods of producing their pattern blocks: frequently they carve them out of solid plaster. This is quite a common method when but two or three blocks are needed to serve for a special purpose. Some expert workmen can carve an entire set of six blocks with considerable success, but this, although a shorter process, often results in poor contours and faulty articulation.

The Plaster Mould.—The first part or design is now completed in the substantial form of plaster blocks, which will be used for the second part

of the process, which is the formation of the plaster mould, sometimes called the plaster model.

The plaster mould is composed of five pieces—the *face side*, the *pin side*, *two end* or *crown pieces*, and *one key*. Before making the plaster mould, a foundation-plate must be prepared on which to arrange the plas-

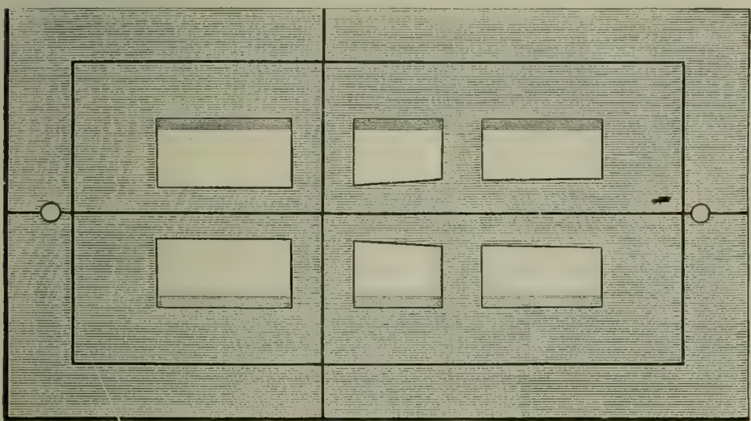
FIG. 902.



Plaster Blocks, finished.

ter blocks. This plate can be made either of wax or brass: the one shown in Fig. 903 is of brass with polished surfaces, and measures five and a half inches long, three inches wide, and a fourth of an inch thick, with holes to receive the blocks: those for the front blocks are one inch long and half an inch wide; those for the bicuspids, three-fourths of an inch long

FIG. 903.



Foundation Plate.

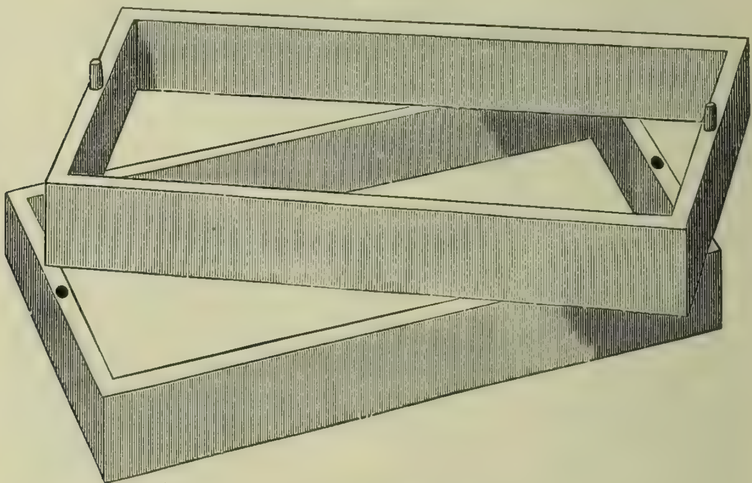
and half an inch wide; and those for the molars, seven-eighths of an inch long and half an inch wide. The lines on the plate are guiding-lines to measure from when setting the blocks; the round holes at the ends are to receive the pins of the frames, which will be described farther on.

The plaster blocks are placed on the foundation-plate face upward,

with the cutting edges opposite to each other, and are then secured in position with beeswax or putty, which is applied underneath. Upon the proper arrangement of the plaster blocks depends the usefulness of the brass mould: to secure this the blocks should be placed by exact measurement, using the guiding-lines on the foundation-plate. The front blocks are secured to the plate two-sixteenths of an inch from the centre line on the plate: the bicuspid blocks, three-sixteenths of an inch from the line; the molar blocks, four-sixteenths from the line. It will be seen that the side blocks are farther apart at one end than the other, which allows for a tapering key: if after the blocks are fastened in the right position there be any spaces between the blocks and the plate, it must be filled up with moist clay or putty. The plate is now ready for the frame.

The frame is composed of two pieces made of polished brass, one section sitting on top of the other, with pins in one section to fit in corresponding holes in the other, as seen in Fig. 904. The inside is

FIG. 904.



Brass Frame.

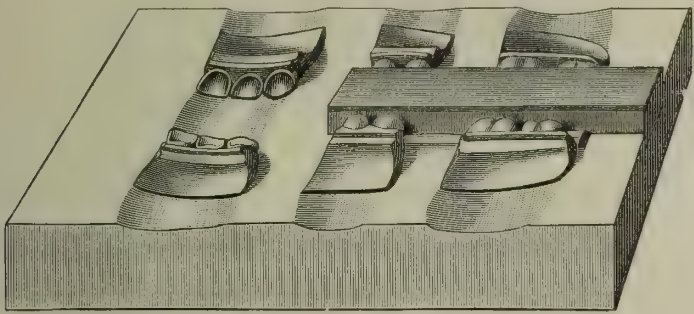
made to taper, so as to deliver the mould. The inside measure is four and three-fourths of an inch long and two and three-eighths of an inch wide; each section is three-fourths of an inch high; the thickness of the rim is one-fourth of an inch.

The section with pins is placed on the plate, and all surfaces that come in contact with the plaster are oiled; the plaster is well mixed and freed from air-bubbles and poured in, and scraped off even with the top. This is the face half of the plaster mould, which is set aside to become hard before removing the plate.

To remove the plate it must be warmed enough to soften the wax, all of which must be removed carefully from the blocks, which are gently taken from the face side of the plaster mould: if any of the edges are broken, they must be replaced with plaster and all edges be made smooth. The blocks being removed, the face side of the

mould must receive a light coat of varnish. When dry the blocks are replaced. A piece of wax is then formed to fill up the space between the bicuspid and molar blocks, as seen in Fig. 905, to form

FIG. 905.

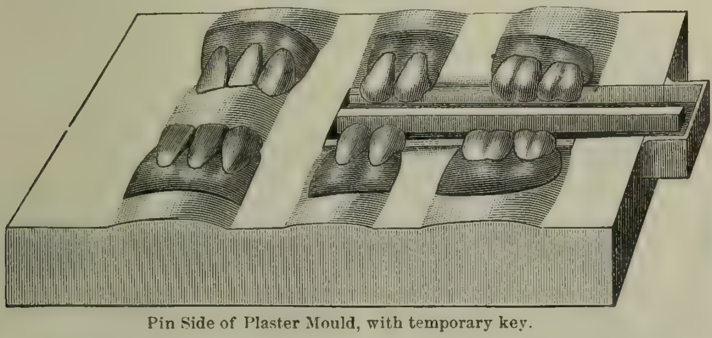


Face Side of Plaster Mould, with plaster blocks and wax in position.

the space for the end pieces and key in the pin side of the mould. All the surfaces are oiled and the whole fixture placed in clean water, in which it is allowed to remain until all the air-bubbles disappear. It is then taken out and the water drained off. The other section of the brass frame is then placed in position and filled with well-mixed plaster: this forms the pin side of the mould. When the plaster is well hardened the parts can be separated by inserting a thin knife-blade between the two sections and gradually prying apart: the plaster blocks will generally be found in the pin side of the mould. Great care is required in removing them, so that the mould will not be injured. The brass frames are then removed from each side of the plaster mould by gently tapping the frame with a wooden mallet. The making of the end pieces is now to be described.

The end pieces form the crown or masticating surfaces of the bicuspids and molar blocks. The key is a wedge-shaped piece of brass, and holds the end pieces in place. The wax must be taken away from

FIG. 906.

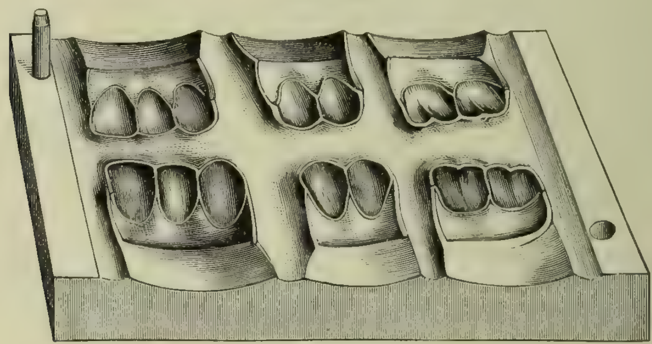


Pin Side of Plaster Mould, with temporary key.

between the side blocks, the blocks also be removed and carefully brushed: the space between the side blocks must be enlarged in width about three-sixteenths of an inch, the floor be made flat, the sides per-

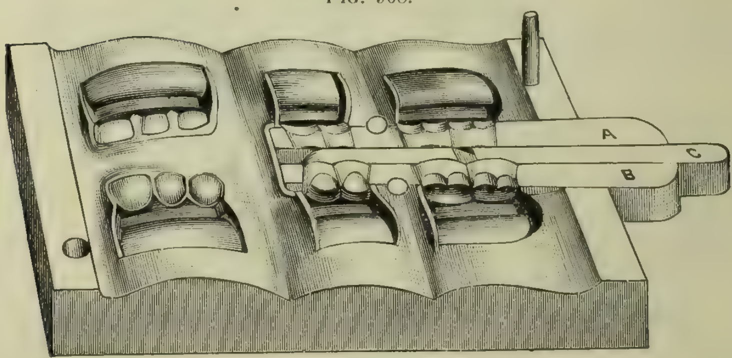
pendicular, and taper toward the end of the mould, which must be wider than the other end of the space; the surface of the space is then varnished. A temporary key of metal is placed midway in this space and fastened with wax: it extends beyond the end of the mould, as seen in Fig. 906, and has under it a piece of wax to keep it in place. The mould is then oiled, and again put into water to drive out the air; the cast is drained from water; the side blocks are oiled and put in place; the face side of the mould is oiled and put in position, and the two sides are tied together. Thin plaster is then run into the space, extending beyond the cast to the end of the key. After the plaster is hard the parts must be separated and all imperfections be removed; all the pieces of the mould must be well dried by a gentle heat before any other work can be done on it: it is then trimmed, and grooves are cut around each block in both sides of the mould to allow for the escape of surplus tooth-composition in moulding teeth. The plaster mould must be made as smooth and perfect as possible, as all imperfections are transferred to the brass castings, and are much more difficult to remove in brass than in plaster. When entirely finished all the plaster pieces of the mould are carefully varnished, and left in an airy place to dry. They are then sent to the brass-founder to be cast in hard brass.

FIG. 907.



Face Side of Brass Mould.

FIG. 908.



Pin Side of Brass Mould.

FIG. 909.

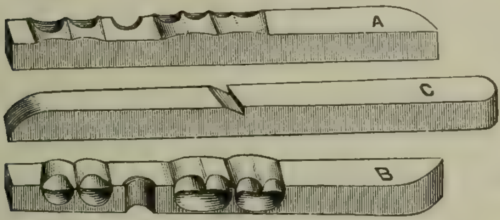
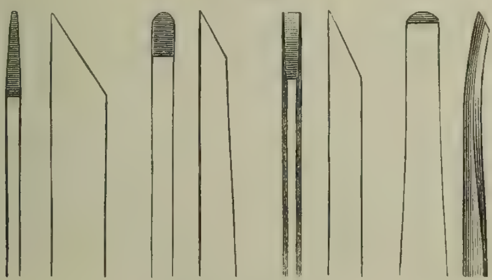


Fig. 907 illustrates the face side of the finished brass mould; Fig. 908 the pin side: at A and B are seen the crown-pieces; C is the key. The heads of the brass retaining-pins are seen between the molar and bicuspid blocks of Fig. 908.

Cutting and Finishing Brass Moulds.—Cutting and finishing the brass casting require a considerable number of tools. The following list comprises the essential ones: two or three flat files, ten or twelve inches long, bastard and smooth-cut, for finishing the outside of the mould; small files, flat and half-round, for the inside; eight or ten gravers of the best quality of steel, flat and round-edged, of different sizes, for cutting the teeth; a bench vise with parallel jaws, three inches wide; an upright breast-drill, with three sizes of Morse drills, for the guiding and end pins; taps and dies for the same; several jeweller's bent rifflers; two pairs of steel dividers; a pair of steel calipers; a steel try-square, four inches long, for squaring up the mould; a hack saw, for sawing off the pins; a steel clamp, to hold the two sides of the mould together when drilling the holes; a thirty-pound anvil; a four-pound hammer; a taper reamer, for the guiding pin-holes and countersink. Fig. 910 represents some of the most useful gravers.

FIG. 910.



Gravers, Stub's steel.

The metal best adapted for moulds is the ordinary brass, with the addition of about 15 per cent. of tin: this will harden it sufficiently to keep the mould from springing out of shape during the moulding process. When the castings are received from the founder the thickest parts will be found so contracted that the outline edges of some of the blocks do not touch when the two parts of the mould are placed together. The high parts must be filed down, so that all of the edges will meet, and both sides of the mould set squarely on each other without rocking.

After adjusting the edges a trial of plaster, pressed between the two halves of the mould, should be taken, to see if they meet properly; then a line must be drawn across the two ends to show where the holes for the guide pins are to be drilled. If the trial with the plaster shows the closure to be correct, the two sides of the mould must be held firmly together with a steel clamp, and the holes for the guide pins drilled entirely through each side with a three-sixteenths Morse drill. The positions for the guide pins are—one in the face side of the mould, opposite the right central; the other in the pin side, opposite the left molar. The guide pins must be permanently screwed one in each side as above indicated, as this arrangement prevents mistakes in placing them together when moulding teeth. After the holes are drilled, the one in the face side opposite the right central, and the one in the pin side also opposite the left molar, must be screw-tapped for the screw end of the guide pins; the other end of the pins must taper a little, so as to enter the hole opposite to it freely. These pins must be made of the best steel wire. After the pins are screwed to the mould the two sides of the mould must be adjusted so as to fit nicely, and then the outside of the mould must be filed square, using the try-square and calipers as guides.

It is very important that the mould, when the two sides are together, should be of the same thickness in every part and perfectly level, otherwise it will be sprung out of shape by the press in moulding teeth. Turning it level in a machinist's lathe is a better method than levelling it by files; the lathe is also useful in the polishing process. The next operation is fitting the end pieces in the space between the back blocks: this must be done very accurately; the floor of the space must be filed flat and perfectly level; the sides are made perpendicular, the end pieces where they touch the key are made smooth, and a taper key is made to fit between them: this key must be made longer than the end pieces to facilitate its removal. To hold the end pieces in place two brass-headed pins are riveted in the pin side of the mould between the bicuspid and molar blocks, as seen in Fig. 908, the pin being partly in the mould and partly in the end piece, which slips under the head of the pin.

The most troublesome and particular parts of the process of finishing are the cutting and smoothing of the inside surfaces of the mould. This is done with gravers, some of which are shown in Fig. 910. The castings are generally quite rough when received from the foundry: the fine lines of the plaster pattern are nearly obliterated, but the general shape still remains. The first thing necessary is to scrape some of the roughness off the surface, using a round-edged graver. A plaster set of teeth must now be made in the mould to show just where the mould must be cut. The graver should be held firmly in the hand, resting the thumb on the mould to guard the graver from slipping. Make a clean and smooth cut, using such sized gravers as will best suit the width of the space to be cut: round-edged gravers are best adapted for the face side, the square for the pin side of the castings. After the first general cutting another trial of plaster in the mould should be taken to see if the edges come together properly with no overlapping. As the cutting

proceeds frequent trials with black try-wax are necessary. Try-wax is made by mixing beeswax and lampblack with a few drops of turpentine, thus making a mass that can be softened by the warmth of the hand. Small pieces of the wax can be held in the hand while cutting, and thus always be ready for use to take impressions of concavities formed by the graver: as the workman becomes expert and the eye accustomed to measure the shape and depth of concave surfaces fewer trials with the wax are necessary. Particular care is required to form the margins around the necks of the teeth, so that they be even, smooth, and sharp, remembering that this is essential to keep the gum enamel from mixing with the point enamel.

The pin side of the mould requires different shaped gravers, mostly square-edged and of several sizes. In some places small bent files, called jeweller's rifflers, can be used to advantage, also square-edged punches for corners and where straight edges are needed.

After the cutting is completed another trial of plaster must be made to determine whether the blocks leave the mould easily with slight tapping; to avoid bruising the mould the tapping is done with a small wooden mallet. If the plaster blocks are difficult to remove, the edges require more tapering: this is better done with square punches, which will leave the surface smooth. Lastly, small holes are drilled in the pin side of the mould for the platinum pins that are to go in the porcelain blocks: these holes are to be drilled *perpendicular* to the face of the mould and *parallel* with each other, five for each front block, four for the bicuspid blocks, and three for the molar blocks.

When entirely finished the mould has to be thoroughly cleaned before using it for moulding teeth: the least particle of brass will ruin the block composition, producing a black spot when burnt. Powdered pumice-stone and water, rubbed on every part with a pine stick, give to the mould a beautiful surface.

Moulding and Burning Block Teeth.

Preparing the Body.—The body should be tempered in a large earthen crock or jar, water being sprinkled upon it to dampen it entirely through. It should be covered with a lid to keep out the dust, and then be put aside for two or three weeks before using it for moulding. It must be examined every few days to see that it does not become dry: if it does, water must be sprinkled upon it. By this prolonged exposure to water the mass becomes more plastic, and at last tough enough to keep its form when moulded. No *metallic* spatula should be used in mixing body or enamel, as the metal wears off and mixes with the composition, coloring it more or less of a blue tint according to the amount introduced into it. Use a bone, ivory, or wood spatula for mixing, as minute particles detached from these by wear are in the furnace burnt out of the body without injury to it. The body when taken out of the crock is loose and porous, and has to be thrown repeatedly on a slab to condense it and drive out the air-bubbles: if this is properly done it becomes dense and workable.

The enamel requires no *ageing*, and only needs mixing with sufficient

water to the consistency of soft putty to be ready for use. The mixing is done on a glass slab with a small bone spatula. Previous to moulding the brass mould must be thoroughly cleaned and oiled and the platinum pins put in the small holes made for them in the pin side of the mould.

Moulding commences with putting the point enamel in the face side of the mould, taking enough up on the enamel tool for each tooth, and placing it in position loosely. When sufficient enamel is thus laid in place, it must be arranged with the enamel tool in full thickness at the point and tapering down quite thin toward the neck. A thin coat of point enamel is placed on the lingual side of the front teeth, also on the masticating surfaces of the bicuspids and molars. When this is done lay aside the mould to dry a little before placing the gum enamel in position.

Manufacturers put but one enamel (point enamel) on the teeth, letting the yellow body show at the neck of the tooth: the body, being opaque, destroys the transparency of this part of the tooth, and to that extent this is an objectionable practice. The correct plan is to use yellow enamels, which give transparency to the whole tooth. Using two enamels requires more careful adjustment of the enamels and a greater expenditure of time, and it is probably for these reasons that manufacturers prefer the former method.

Placing the gum enamel is generally considered the most particular part of moulding, it requiring unusual skill and judgment and being entrusted only to trained experts. The gum enamel is kept in a porcelain jar, and when slightly moistened with water is ready for use. A sufficient quantity is lifted with the enamel tool and placed on the back of the left hand between the thumb and forefinger: a very few drops of water added to it will bring it to the right consistence; it must not be thin enough to run, but just stiff enough to stay where it is placed by the enamel tool, by which it is spread evenly over the gum surface of the mould, this being done by drawing the gum enamel over the surface, and at every eighth of an inch touching the point of the tool to the mould. This lifting of the tool and touching the mould with it as the gum is drawn over the surface by it regulates the thickness of the enamel. The gum enamel is placed close to the necks of the teeth, and is then allowed to stand a while to get firm.

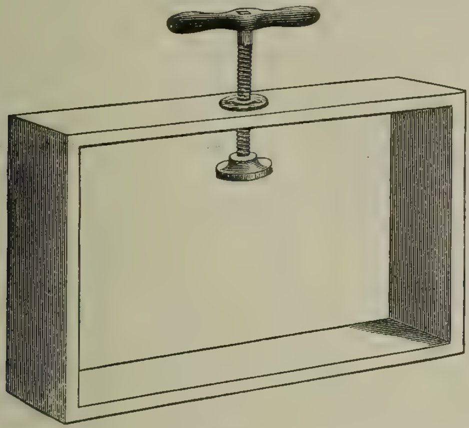
Small pieces of the prepared body a little more than sufficient for each block are then taken up with the small bone spatula, formed into balls, and laid on the pins of the pin side of the mould: this must be done carefully, so that, once placed, the pieces of body may not be again lifted; which movements would bring the pins out of the mould and mix them with the body. The two sides of the mould are then placed together quickly, put in the press, and the lever applied to force the two sides of the mould together.

When taken from the press the mould is put in a clamp and screwed firmly for the purpose of holding it while it is heated on a stove. When the mould becomes hissing hot it is taken off, and is allowed to become cool enough to handle: it is then unclamped, the mould opened, and the teeth jarred out by striking the mould with a small wooden mallet.

The teeth are received on a wooden frame eighteen inches in diameter, which is covered with stout muslin: falling on the muslin prevents injury to the blocks.

If properly heated the blocks will be found quite hard, but they can be easily trimmed with a file and the teeth be separated with a thin-bladed saw which is made for this purpose. On looking over the for-

Fig. 911.



Clamp.

mulas for bodies it will be observed that one of the ingredients is starch: as previously explained, the purpose of its introduction is to harden the block for trimming and to facilitate the after-handling, the heat and moisture converting the raw starch into a gum, which is burnt out of the body in the furnace without injury to the composition.

If a block should receive a slight injury in moulding it can be restored with enamel before placing it on the slide. After trimming, the blocks are laid aside in complete sets for burning.

Burning.—For burning, fireclay slides are necessary: these are covered with coarse quartz, upon which the blocks are arranged in complete sets, each set occupying one row across the slide; twelve or fourteen sets can be set on each slide. These slides measure six and a half inches in width and nine and a half inches in length: they are made of the best prepared fireclay, and have a raised edge to prevent the quartz from jarring off. They hold from twelve to fifteen sets according to the size of the blocks.

The following is a description of the furnace-room of Mr. Gideon Sibley of Philadelphia, which is well arranged and complete in its appointments, it having a capacity of about three or four hundred sets per day for one furnace. The building is one story in height and is built of brick. On entering the room four furnaces and a smokestack are seen built against the wall: the smokestack rises from the ground to a considerable height above the roof, and is provided with a damper on top so arranged as to be operated from the inside in regulating the draft. Two furnaces are built on each side of the smokestack. The outside of the furnaces is built of ordinary red brick held together with

iron bars; the inside is made of firebrick. These furnaces are square, with a heating-oven directly over the fire, the muffle being placed farther below: flues across the top connect these furnaces with the smokestack.

The muffles for the above furnaces are twenty-seven inches long, eight inches wide, five and three-quarter inches high, inside measure, and one and a quarter inches thick.

The cooling muffles or ovens are arranged at each end of the room: they are built against the brick wall, and are made of flat pieces of firebrick about twelve inches square. They are separated by low partitions of the same material in tiers of ten in each row. The tiers are ten, numbering eighty or ninety: each oven has a loose firebrick stopper.

Each furnace takes a charge of nearly half a ton of coal: the coal must be the best Lehigh, and be carefully selected before using in the furnace. The most serious accident in burning teeth is caused by gas leaking through the muffle, the gas generally coloring the teeth blue, but sometimes producing a reddish tint. Certain kinds of coal throw off more gas in combustion than others: experts in burning say they can tell pieces of these kinds of coal by sight, and reject them when making the fire. The only remedy I know of is swabbing the muffle with clay to fill up the pores before burning.

The slide, with the teeth arranged on it, is always placed in the heating muffle at the top of the furnace before burning: this saves time. When ready it is lifted on a flat iron shovel, placed in the muffle, and the door closed.

The length of time for burning each slide of teeth varies according to the heat of the muffle, the first and last slides taking more time than those between. Better results are obtained if they are properly burned in fifteen minutes: this allows the enamel to fuse slowly without mixing with the body, and also prevents the colors from vaporizing, as happens in quick and extreme heats. When the teeth glaze in less than fifteen minutes the damper should be closed a little to diminish the draft; if it exceeds fifteen minutes, the damper should be opened.

When the teeth are properly glazed, which can be seen by placing them under a gas-jet, they are put in the cooling muffle, the door of which is then closed; from this they are not removed until entirely cold.

Carving Block Teeth.

Carving teeth in soft tooth-composition may, to the uninitiated, seem a very simple and easy process, but a few attempts on the frail material with the delicate knife will show that it, like other arts, has a technique of its own, requiring a special education and skilful manipulation to make its successful accomplishment possible. If the student has some previous experience in the arts of drawing and modelling, it will be of great assistance to him; for an acquaintance with the lines, angles, and curves of drawing, as also with the contours and profiles in modelling, gives ability and confidence to the learner, whose efforts without this knowledge might end in discouragement and ultimate failure. With some artistic ability and considerable patience no failure need be anticipated.

Hand-carved blocks have the merit of being the most natural-looking, and at the same time, when well mounted, the strongest, artificial teeth made: other styles, such as continuous-gum and single teeth on celluloid, can be made to look very natural, but, unfortunately, they are not strong and lasting, and are generally more or less disfigured when repaired: they also have to depend on such teeth as the dépôts have on hand, which rarely come up to the requirements of the case either in shape or color, thus necessarily resulting in an artificial expression.

When the best results are desired, and neither time nor cost is an object, carved blocks are the best recourse of the dentist. It is here that the artist has an opportunity and a free hand to carry out his conception of some difficult and peculiar case, the soft tooth-composition being favorable to the quick and easy execution of his design. The teeth can be placed in any position or inclined at any angle deemed desirable. If the first carving is incorrect, the miscuts can be filled up with the brush and recarved, thus giving every opportunity for correct adaptation and natural effect.

A close observer will discover wherein lies the difference between carved and moulded blocks: the natural expression of carved work is seen in the bolder curves and contours made by the skilful hand, which it is impossible to produce from brass moulds. The slight difference in size and shape between the right and left lateral and eye-teeth—which to some extent is inseparable from hand-work, and which difference, if slight, is not objectionable—gives a natural effect that is a decided advantage: as in the natural jaw, homologous teeth are never the exact counterparts of each other; therefore slight differences give natural effects.

The relative amount of materials in tooth-composition varies according to the kind of base it is intended for or the style of attachment to the base: for carved work it can be made stronger by a greater proportion of the strength-giving materials, such as clay and quartz, or the same object can be attained by decreasing the amount of spar, as will be seen by consulting formulas on p. 963. Clay and quartz also give stability to the blocks in the burning process, decreasing the liability of warpage or sprawling of the teeth.

Early Methods of Carving Blocks.

After these preliminary remarks a brief description of the early manner of carving blocks will serve as an introduction to the later and better process. The early manipulations in this art were few and simple, and every improvement from that time to this has been the outgrowth of necessity, showing the truth of the old adage that "Necessity is the mother of invention."

The first porcelain teeth manufactured were ill-shaped, with hideous colors, and were fastened by being soldered to a piece of gold wire, the ends of which were wound around natural teeth conveniently situated for holding the artificial teeth in position. Human teeth also were riveted to wire, and the same method used to support them in the mouth. These

airy structures were full of spaces ready for the lodgment of food, which soon became offensive.

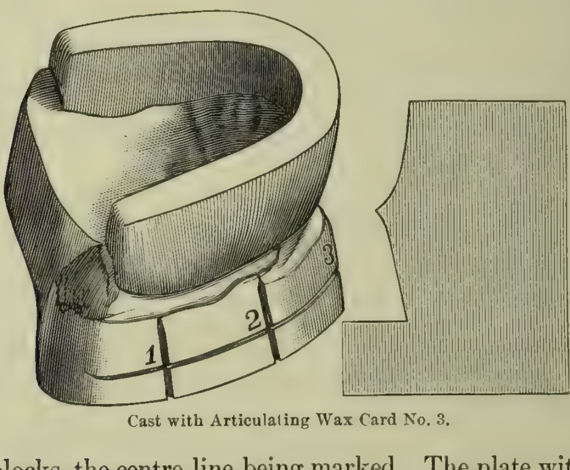
Some improvement became essential. The substitution in the place of wire of the gold plates, which came into use about that time, did not remedy the trouble to any great extent, so that, as already stated, a new form of teeth was soon introduced, called block teeth. This improvement consisted in moulding the tooth-composition when in its plastic condition on the plate, whence, after being partially dried, it was removed, carved into teeth, enamelled, and burned. Thus carved blocks came into use. The first blocks carved were clumsy and the material very poor, with holes drilled vertically for rivets to fasten them to the plate.

Much secrecy existed among the early tooth-makers concerning the materials and formulæ for blocks; which secrecy was needless, for some of the materials employed were useless, and others injurious, such as queensware, French china, Wedgewood, chalk, pumice-stone, borax, phosphate of lime, litharge, etc.

Slowly in course of time, as the result of experience and experimentation, the qualities of different materials became better understood. The useless ones were discarded, the essential retained. Among these latter, as previously shown, were spar, that gives transparency; clay, tenacity and strength; silex, which, being infusible, gives stability and density. As these facts became better known artificial teeth were improved in appearance and utility.

The following is a description, in detail, of the carving process in general use about the year 1840: After the preliminary operations of fitting the plate and getting the articulation were completed, the process was to trim the articulating wax to the exact fulness and height of the

FIG. 912.



Cast with Articulating Wax Card No. 3.

proposed blocks, the centre line being marked. The plate with the trimmed wax was then placed on the plaster cast; five perpendicular grooves about one-sixteenth of an inch deep were cut in the cast with the edge of a half-round file; these grooves were for the purpose of trying the

guide-cards in position, as seen in Fig. 912. The edges of these cards were cut to fit the outside of the wax and grooves in the cast, passing underneath the bottom of it as represented. A longitudinal groove was made around the cast, parallel with the top edge of the articulating wax, to use as a base-line when measuring the height of the blocks; a pair of dividers was used to dot the line, and the exact distance apart of the divider points was marked on the cast for reference.

The articulating wax was then removed, and the plate cleaned for moulding. The tooth-composition—technically called *body*—was then with a bone spatula mixed with a sufficient quantity of water to form a dough, after which it was thrown repeatedly on a glazed tile to toughen it and drive out the air-bubbles. After becoming plastic a piece was separated from the mass, moulded on the plate, and then gently heated by throwing the flame of a spirit-lamp upon it. After driving off the water until it became firm enough, grooves were then cut in the body, using the guide-cards to give the depth: the contour of the block was cut from one groove to the other; the height of the block was obtained by using the dividers opened to agree with reference-marks, plus the allowance for shrinkage, one foot of the dividers on the base-line, the other marking the height on the body.

After the block was cut down to the proper height with allowance for shrinkage, the width of the teeth was marked off; the teeth were then carved into shape. A ledge was cut on the inside for drilling the rivet holes, one being placed directly behind each tooth; after which the inside was trimmed and the blocks dried and biscuit-burnt. The blocks were then enamelled and burnt to a full vitrification. For a full denture three blocks were usually made, the six anterior teeth constituting the front block, the molars and bicuspids the side blocks.

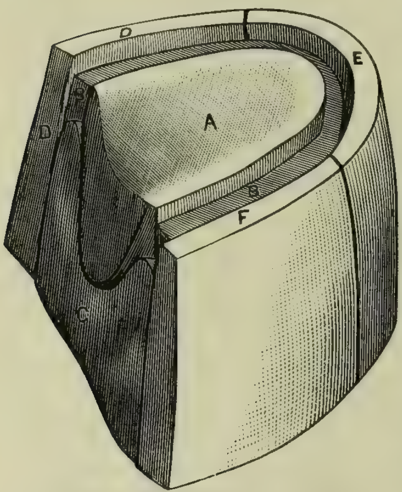
There were two important defects in this process of carving blocks: the first was in the moulding, it requiring so much body that the contraction of the mass in drying frequently cracked it, thus necessitating frequent trials before a good block was obtained. The second defect was in the mode of fastening to the plate by rivets. These became loose, and soon wore out from the plate. At the present time they are seldom made, platinum pins being now inserted in the blocks for soldering to the backings and plate.

Modern Process of Carving Blocks.—The present plan of moulding does away with guide-cards, and substitutes outside and inside walls of plaster. A different way of mixing the body has also been introduced: this will be described farther on.

Walls.—The articulating wax must be trimmed so as to be perfectly correct—outside for the contour of the arch, inside for the thickness of blocks. It must be made of hard white wax, so that it can be tried in the patient's mouth to prove its contour and length. Concave retaining-points are then cut in the sides of the cast to hold the walls in position. The cast is varnished, and when dried is oiled to receive plaster, which is mixed rather thick and moulded on the cast and wax articulation, letting the plaster cover the retaining-points and pass over the edge of the wax, so that it may be somewhat higher than the articulation. This wall is sometimes cut into three sections, the cuts being

between the cuspids and bicuspids: it can, however, be left whole. A surplus groove must be cut at and below the edge of the gum as a vent for the excess of composition. The block surface of the wall must be lined with tin-foil, using shellac varnish to fasten it. The inside wall is made in the same way, and is also lined with foil. Fig. 913 shows the cast with the articulating wax and the inside wall (A) and outside walls (D, E, F) in position. Fig. 914 shows all the pieces separately: A, the inside wall; B, the articulating wax; C, the model or cast; D, E, F, the outside walls.

FIG. 913.



Walls and Articulating Wax in Position.

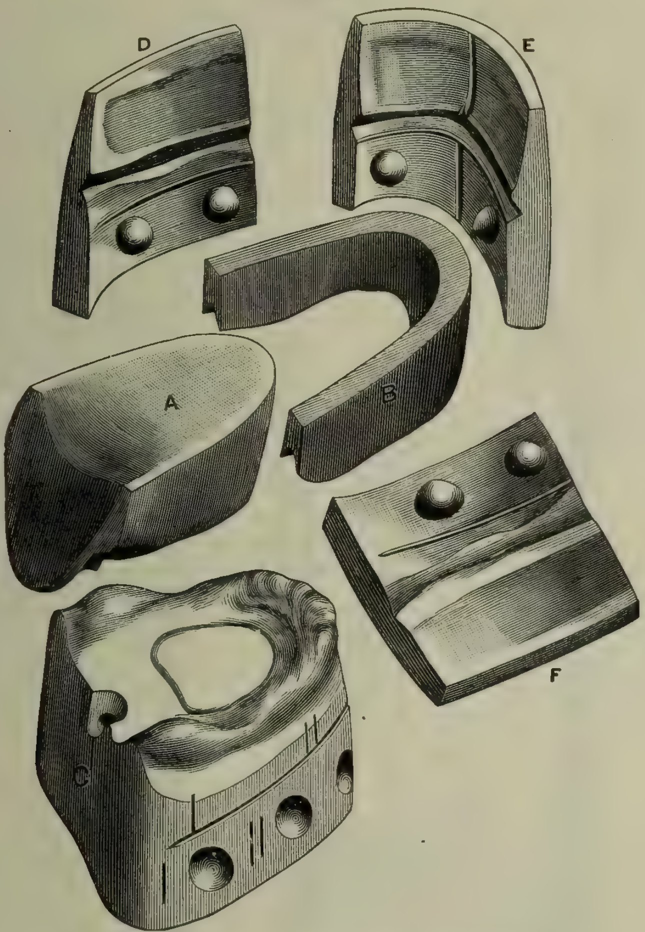
Mixing and Moulding the Body.—Fresh body mixed with water is generally too friable to mould nicely: it should have incorporated with it gum tragacanth; eight grains to the pound of body is sufficient for the purpose. Body becomes tougher and more plastic if kept wet for several weeks with water.

The composition is mixed in a Wedgewood mortar to the consistency of cream, and is then poured into a porcelain bowl to settle: this will take some ten or twelve hours. The clear water on top is then drained off by tipping the bowl, applying a bone spatula to the edge of it to prevent loss of the composition. The body in the bowl must be mixed again very carefully, as some of the coarser parts settle to the bottom: this must be done by passing the spatula through it edgeways, to prevent air-bubbles from entering. Slightly jarring the bowl on the table will throw the air to the top. Set it aside again to settle, and drain off the clear water as before. When it becomes of the proper consistency pieces can be cut out for moulding. Cover the top of the bowl with a piece of glass to keep out the dust.

The walls and cast are then oiled, with the inside wall in place. A small piece, a little larger than is sufficient for the block, is cut out of the prepared composition in the bowl and worked to a convenient shape on a *glass slab* or *porcelain tile:* it is then carefully lifted, with a sliding motion, from the slab and put on the cast with the fingers: a few taps with the forefinger will form it. The outside wall must then be quickly applied and pressed firmly to its place, and held there until the body is dry enough to remove. The drying is done by heating the outside wall with the flame of a spirit-lamp. The wall is then removed, and the moulded block carefully taken away and placed on a glass slab to dry in the air for an hour or two, when it is ready for carving. A serious annoyance in moulding is the occasional occurrence of air-bubbles in the body: these are caused by careless handling of the composition in moulding. The body in the bowl, if properly settled, is entirely free from them,

but the body, being plastic, adheres to the fingers and lifts the mass from the slab, thus allowing the air to rush underneath, so that when pressed down again some of the air which forms the bubbles is enclosed and mixes with the body, unseen by the operator until after the block is burnt. To prevent this, handle the soft composition as little as possi-

FIG. 914.



View of Walls, Articulating Wax, and Cast, separated.

ble, and do not lap one piece of body over another unless both surfaces are entirely smooth.

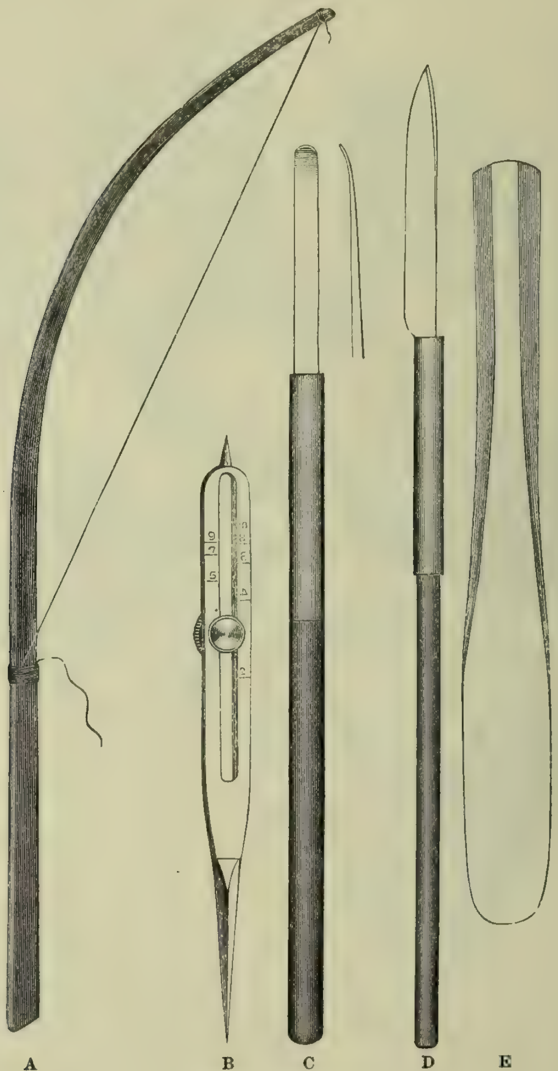
Tools required in Carving Blocks.—Figs. 915 and 916 show the carving instruments: A, string bow; B, proportional dividers, half size; C, enamel tool; D, carving knife; E, bone spatula; F, spoon scraper; G, drill; H, excavator for cavities; I, pin tweezers. (All but the dividers are engraved full size.)

Carving.—Before commencing this process the size and shape of the

teeth must be decided upon, and the whole plan or design well arranged and matured: in fact, the perfect form of the ideal teeth must be in the mind's eye.

Block-body contracts about one-ninth of its bulk in the burning pro-

Fig. 915.



A B C D E

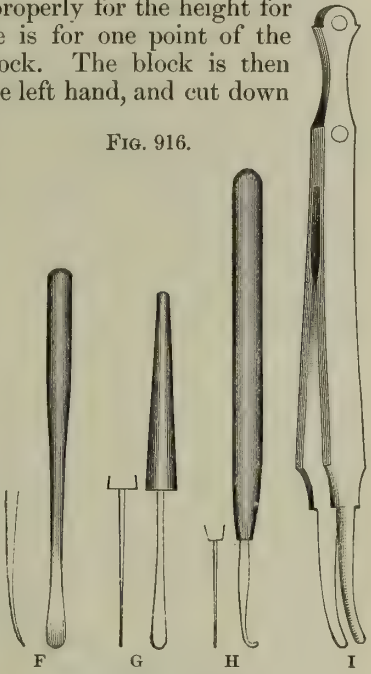
Carving Instruments.

cess, but it is best to allow one-eighth, which will make up for loss in grinding to fit the plate. The measurement for shrinkage is made with a pair of proportional dividers set to one-eighth increase, using the short points to measure the articulating wax from gum edge to articulating

edge: the long points will give the increase for shrinkage. The respective distances are seen on the cast in Fig. 914.

The block must first be cut down to the right height by placing it carefully on the plate and against the inside wall, and scribing with the dividers, which are adjusted properly for the height for shrinkage: the horizontal or base-line is for one point of the dividers, the other is placed on the block. The block is then removed and placed on the fingers of the left hand, and cut down to the line marked on it. The knife is a small blade of a penknife securely fastened in a broach-handle. The block is placed on the inside of the first two fingers of the left hand, the thumb holding it in position for carving, as seen in Fig. 917. (In the engraving the teeth are somewhat distorted.) It must be remembered that the block in this state is very fragile, and must be held lightly, so as not to crush it, nor yet so loosely as to let it fall.

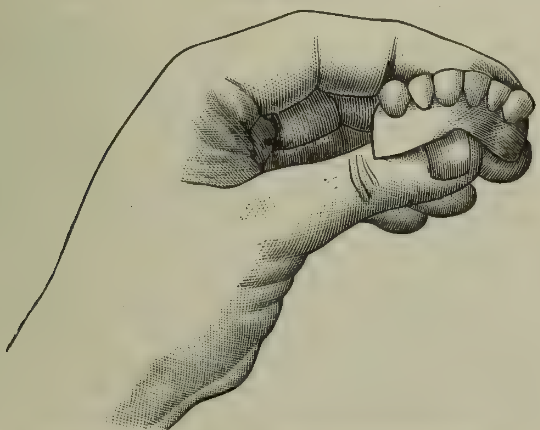
FIG. 916.



Carving Instruments.

The width of the teeth is then marked off on the block, beginning at the centre line: if the central be medium in width, the laterals should be two sizes narrower, the eye-teeth one size narrower, than the central. A size is the one forty-eighth part of an inch: a steel rule divided into fractional parts of an inch will be found useful for this purpose. Assuming that the porcelain tooth selected for color and size is medium—which is about sixteen forty-

FIG. 917.



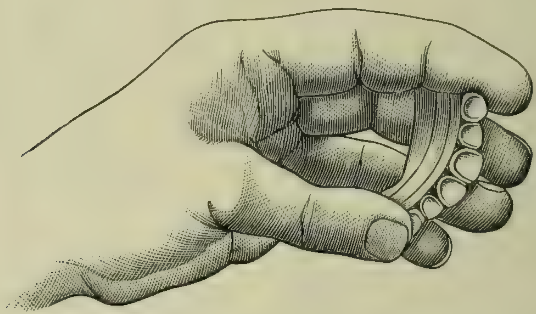
Method of Holding Block when Carving the Labial Side.

eighths of an inch wide—the width must be increased to allow for shrinkage. The small points of the proportional dividers are used to measure the sample tooth; the large points give the increase.

The first carving is merely superficial, not in full relief, as illustrated in Fig. 917. This is to leave room for the enamel, on which the carving is completed.

The carving is commenced by cutting an inverted V-shaped space between the teeth: the block is then turned gum upward. The necks are carved in a semicircular groove, not deep. Care must be taken that the teeth incline toward the centre equally on both sides: in the first few lessons students slope the teeth all one way, like letters in writing. The block is again reversed, and the points of the gum between the teeth are carved down, and both ends of the blocks cut square for jointing to the side blocks. Lastly, the inside is trimmed out to the proper thickness. If it is to be mounted on rubber base, a recess must be made for the pins, as seen in Fig. 918. If the block is very

FIG. 918.



delicate, the pins can be put in after it is biscuited, but if it can be handled with safety, they had better be inserted before. The block is then ready for biscuiting.

The drill for drilling the holes is made of a piece of No. 20 steel wire, the end flattened to be as wide as No. 13 of standard wire gauge; the wire must be annealed before it is flattened. The handle is of light wood and tapered, as seen in G, Fig. 916: it is rotated between the thumb and finger when drilling. Another style is also much in use, the cutting point of which is twisted like a carpenter's auger-bit: a spoon-shaped scraper is also shown for other delicate work.

After the holes are drilled the pins are put in and a thin mixture of body and water floated around them. Care must be exercised that the mixture goes down to the ends of the pins.

Biscuiting.—Biscuit-baking is the hardening of the blocks in a red-hot muffle: it is necessary for thin and delicate blocks in order that they may be handled without fear of breaking. They are laid on a "slide," a fireclay slab, and thoroughly dried by a gentle heat before they are placed in the muffle. In the muffle they are allowed to get to a bright-red heat, and are then removed and cooled in the open air. While in the muffle the heat must not be urged higher than a bright red, for then

the composition will become too hard to take the enamel: about the hardness of chalk is best.

Enamelling.—Enamels should be kept in a dry state in wide-necked glass bottles. When needed for enamelling small quantities can be mixed in small glass jars provided with lids to keep out the dust. Cold-cream jars are well adapted for this use. A jar must be provided for each enamel, and a label pasted entirely around it with the number and color of the enamel plainly written upon it. If the enamel dries and becomes hard, it can be ground in a glass mortar while dry; but it must be remembered at the same time that the transparency of spar can be ruined by too much grinding. Feldspar when lightly ground or crushed gives the best results.

Enamelling requires more skill than any other part of block-work, as the majority of failures occur here. They are generally due to the fact that the enamel is placed on the block carelessly, without observing the thickness or whether it unites with the body or not. The coat of enamel on the teeth and gum, after being trimmed, should be at least the one twenty-fourth part of an inch thick: less than this will not develop the full translucency of the spar or brilliancy of the colors. The body, having clay in its composition, is opaque, and will show through a thin coat of enamel, thus giving a flat and lifeless look to the whole work. The enamels should never be used without mixture with gum arabic to keep the spar and coloring materials from settling: fifteen grains of the gum to each ounce of enamel will make it work smoothly and enable it to be handled when dry without rubbing off. The gum arabic is a vegetable product, and burns out at a red heat without injury to the composition.

Enamels are technically called neck, point, stain, and gum enamels. The *neck* enamels vary in color from *light yellow* to *dark brown;* the *point*, from *white* to all the different tints of *blue-gray*, and *yellow*; the *stain* enamels are the darkest *brown* and *olive* colors; the *gum* enamels are the *red* or *rose* and the *light* and *dark purples.* The enamels are applied to the blocks with *camel's-hair pencils,* from the smallest or miniature size to the full goosequill: the largest size is for water-brushes in carving.

Enamels should be mixed with clean water in small glass or porcelain cups, making a cream-like solution. The first coat is put on the necks of the teeth, letting the enamel run to near the cutting edges or points of the teeth, applying it thickest where the tooth adjoins the gum, tapering in thickness to near the point; at the cutting edge and immediately above it no neck enamel is allowed to remain. In applying the enamel the block is held gum upward. Be sure that the enamel closely adheres to the body: if any creases show, they must be wet down by touching them with a little water, and all ridges must be smoothed or trimmed down with the small knife used for carving.

In applying the point enamel the block must be reversed, teeth upward: fill the brush partly full of the selected point enamel, and apply it lightly on the cutting edges of the teeth, about one twenty-fourth of an inch thick; then with a tolerably full brush sweep downward toward the neck of each tooth. Be sure to cover all the neck

enamel, but quite thinly when near the gum: full thickness is given at the cutting edge of the teeth.

It requires some practice to lay on the point enamel without wiping off the neck enamel at the same time. The proper way to avoid this trouble is to bear lightly on the brush. After the brush is full of enamel it must be passed lightly over the teeth, so as to let the enamel flow or be drawn from off the point of the brush upon the block: this will prevent mixing the two enamels, which mixing spoils the effect of each. If the edges are uneven, wet them down by touching them lightly with the water-brush partly full of water: be sure that the enamel flows well between the teeth.

The enamelling being complete, the carving is begun by separating the teeth from each other by a string bow made of a piece of whalebone six inches long, the ends being tied together with spool cotton. This is a much better way of separating the teeth than by a thin saw or by the knife. The block being still held teeth upward, the teeth are further separated at the neck by cutting inverted V-shaped spaces between them: the position of the block is again reversed, gum upward, and the neck formed by carving it more or less in a semicircle.

Contouring the face of the teeth from the neck to the point is the most important part of carving, and the form depends on the style of teeth needed for the case in hand: these forms are *round-faced*, *semi-round*, and *flat-faced*, and each of these classes have *narrow* and *broad necks* respectively. The proximal edges or profiles are from nearly a straight line to an *ogee* curve: these face and profile curves will be better understood by reference to the annexed drawings.

Consulting the figures, the teeth of Fig. 919, it will be seen, are round-faced; Fig. 920 shows side and end views of the same teeth.

The teeth in Fig. 921 are semi-round; Fig. 922 shows side and end views of the same.

The teeth in Fig. 923 are the flat-faced; Fig. 924 gives end and side views of the same.

Fig. 925 shows lower incisors and cuspids; Fig. 926, bicuspids and molars.

The shapes of the above teeth are somewhat conventional, having been adopted as about the nearest resemblance to nature that can be conveniently carved in such soft and friable material as block-composition. The necks seem too narrow in width, but after being separated with the string bow and the shrinkage in burning—which shrinkage is more in proportion at and near the cutting edge—brings them more in accordance to the natural shape.

The shapes represented by Figs. 927, 928, 929, 930, and 931 are facsimiles of natural teeth, given more especially to show the wide range of size and shape existing in the natural organs. They also show the necessity of having some systematic plan for carving teeth that will include the general characteristics of natural teeth, so that a close similarity may be obtained.

Placing the Gum Enamel.—The gum enamel, being somewhat coarser than the other enamels, settles to the bottom of the cup unless it has more gum arabic than the point and neck enamels: twenty grains to the

FIG. 919.

FIG. 920.

FIG. 921.

FIG. 922.

FIG. 923.

FIG. 924.

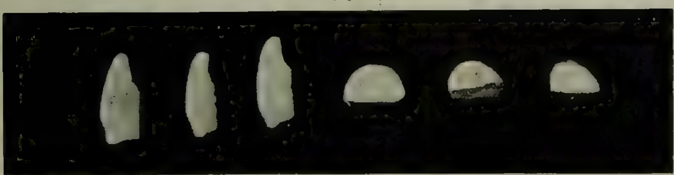


FIG. 925.

FIG. 926.

FIG. 927.

FIG. 928.

FIG. 929.

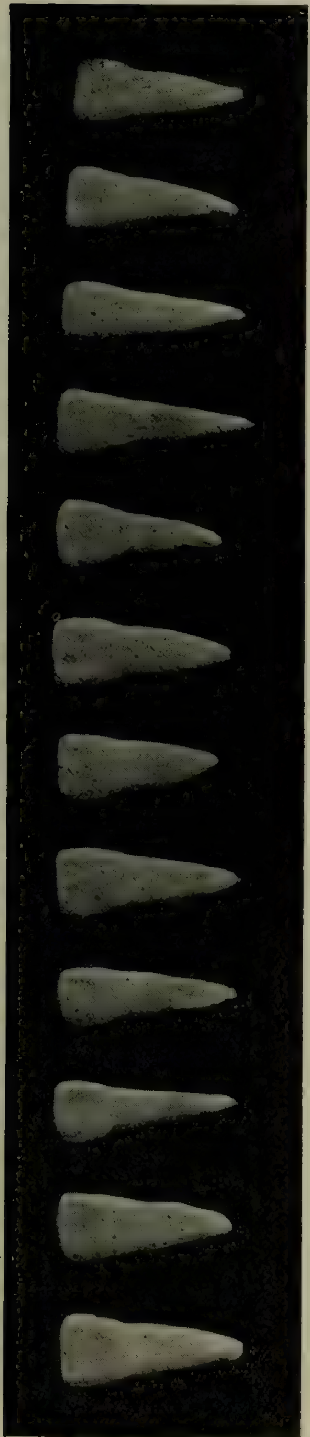


Fig. 930.

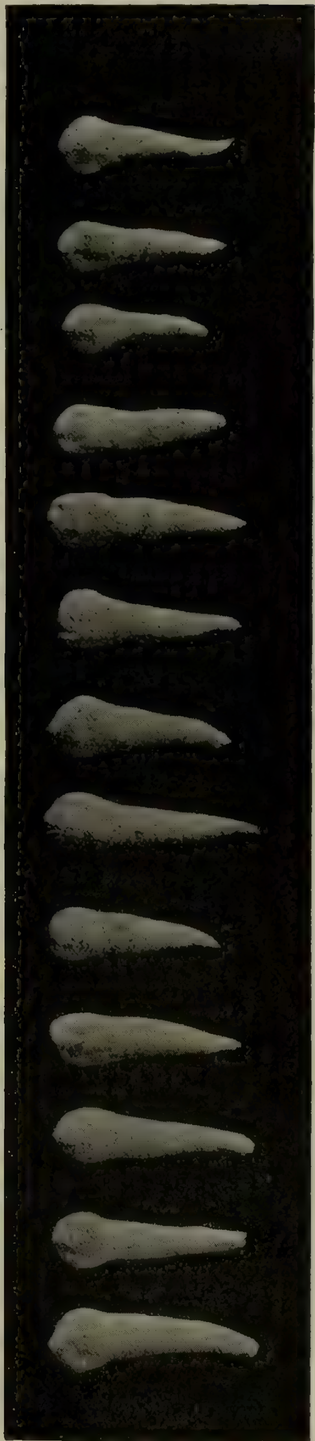


Fig. 931.

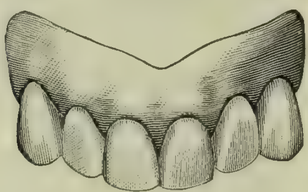
ounce of enamel is sufficient. The gum enamel is applied to the points between the teeth with the carving knife; the rest is put on with the brush, care being taken to place it close to the neck of the teeth, but not to overlap the other enamels. A little water from the point of the knife will unite them to each other. It is not best to make the gum enamel very smooth; it fuses at a little lower heat than the point enamel and is apt to become glassy.

Gumming, as it is technically termed, is generally very poorly done, with the result that a dull purplish-red color is produced. The festoons around the necks of the teeth should be tastefully ridged, and the rest of the surface be a little mottled by leaving it thicker in some places than others. This gives it a bright and life-like look, but judgment is necessary in putting these thick and thin spots in the right place; they should not be made either large or conspicuous. These inequalities in the surface of the gum break up the glaring look that a smooth and even surface of fused enamel has.

A close inspection of a fused piece of gum enamel through a magnifying-glass of low power is a beautiful revelation of how heat dissolves the grains of gum frit in the transparent medium of good spar, showing how they melt away in the surrounding flux into still smaller particles and become diffused throughout the mass of fused material, thus reproducing the effect of the blood in the natural gum.

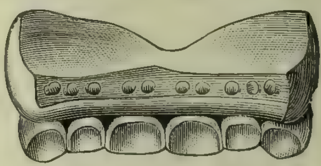
The last operation is washing the inside of the teeth and block with a thin coat of point enamel as a glazing to the rough surface of the body. The block is then set aside to dry previous to burning. (Figs. 932 and 933 show the finished front block.)

Fig. 932.



Labial Side of Finished Block.

Fig. 933.



Lingual Side of Finished Block.

Blending the point and neck enamels is not done by mixing the thin edges of the two enamels together, as is generally supposed, but by the lapping of the thin edges of each: the more gradually this is done the better the effect.

Curves, lines, and especially sharp corners, are very much altered in the burning process. The enamel assumes more or less the globular form when it becomes softened in the extreme heat of the furnace: this must be remembered in carving teeth, so that due allowance be made where sharp corners and curves are desired.

A transparent enamel is an absorbent of light, and will harmonize with other colors that are quite different in hue: it is this transparency which gives such a soft, mellow look to the best quality of fused spar; it also gives greater depth to the color of enamels. For these good qualities the best spar should always be selected for enamels.

An opaque enamel, on the contrary, is a reflector of light, and is very different at night from its appearance in daylight. Dark, opaque colors are very harsh and dead-looking, but by using the best spar considerably less color is needed for the same tone or shade.

A pure white enamel is also a reflector of light, and necessarily opaque; fortunately, a white enamel is very rarely needed in carved work, except for imitation of spotted teeth. White opaque spots are frequently seen on natural teeth: these can be imitated with an enamel made as follows:

Kaolin,	$\frac{1}{3}$ oz.	
Feldspar,	1 "	Mix.

After the teeth are enamelled small holes, the size of the intended spots, are cut into and through the enamel, and are then filled up even with this opaque enamel.

Staining Teeth.—Stains of various tints can readily be put on carved teeth. A slight groove is made at the proper place, and the stains put on with a very small brush: the colors should be ground very fine. The following formulæ may be used:

Dark-greenish Stain:	Platinum sponge,	5 grs.
	Titanium oxide,	10 "
	Feldspar,	10 "
	Enamel flux,	2 "
Dark-yellow Stain:	Titanium oxide,	20 grs.
	Gum frit,	4 "
	Enamel flux,	2 "
Black Stain:	Iron scale,	10 grs.
	Feldspar,	5 dwts.

The formula for enamel flux is—

Carbonate of potassium	1 oz.
Glass of borax (powdered)	1 "
Quartz (powdered)	4 "

Mix and pack in a light-colored crucible well lined with pulverized quartz and tightly covered. Fuse to a transparent glass. Pulverize and keep dry for use.

These stains vary in depth of color according to the amount of grinding they get: they should be kept in glass bottles, with fused trials fastened outside for reference.

Among titanium-oxide crystals impure specimens can often be found of an olive-yellow: these make very good stains when ground and mixed with feldspar.

Some of the well-known rules for mixing colors in the art of painting must also be carried out in coloring enamels for artificial teeth—notably, the primary colors, such as the oxides of titanium and uranium, the blues of cobalt and platinum, and the bright red sometimes used for gum-color. These are too brilliant to be used alone: they must be subdued in tone by combination with one or two other colors, as before explained.

A green tint, which is a mixture of yellow and blue or the shade which

is produced when a blue overlies a yellow, should be avoided as much as possible; as also should violent contrasts of color, such as a bright blue placed sharply next to a bright yellow. These incongruities in coloring show defective education in art, and, as they look unnatural in the mouth, they invariably draw attention to false teeth, which the generality of people object to.

Cavities for filling are often demanded, they being preferably placed in the front teeth to show to the best advantage. These cavities are usually cut with the finest-pointed knife, and generally with poor success. The surest way is to model a piece of paraffin the exact size and shape wanted, letting it into the enamel by cutting a hole of sufficient size to receive it, and close around the edges with a little more enamel to make the edges as sharp as possible, as they round somewhat in burning. Avoid placing many cavities in one block: it is not in good taste.

Another Process for Moulding Block Teeth.

Various methods have been tried to carve teeth more expeditiously and with less liability to accidents than the old plan just described, the main idea being to *mould* instead of *carve* the teeth, thus saving time and possibly the lack of the necessary artistic talent essential in copying the natural teeth.

The plan most largely followed among carvers was to select a set of plain teeth a little larger than those wanted—which extra size was an allowance for shrinkage—press the teeth into the articulating wax in the right position, and run plaster walls over them after the same manner as was described for making plain walls. After the removal of the plain teeth the walls were trimmed and lined with tin-foil, the depressions where the teeth came from being smoothed with a burnisher with special care. Previous to enamelling the walls were oiled, the enamel then packed and body moulded in the usual way.

The difficulties of this plan, however, are numerous, such as the trouble in getting the proper-sized teeth, removing the plaster walls

Fig. 934.

Biscuited Teeth.

from the teeth, patching up the broken edges around the teeth, the enamel frequently sticking to the tin-foil and breaking away in the removal of the walls in moulding, sometimes taking the entire tooth off. These and smaller difficulties soon led to the abandonment of the

process, although at one time it was very popular and was taught in the schools.

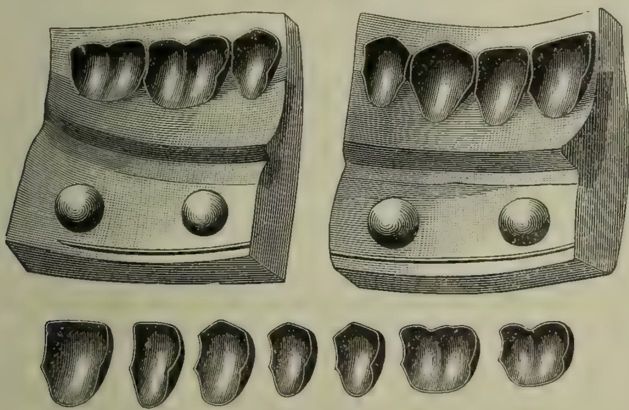
Another process suggested to the writer the feasibility of using biscuited plain teeth placed in position while the body was soft. Fig. 934, front and side views, shows the style in which these teeth were made. The first few trials were so promising that the writer was induced to manufacture several brass moulds of peculiar shape to make the plain teeth. After going to considerable expense and through many irritating disappointments, caused by the non-union of the biscuited teeth to the soft body—which always showed *after* the block was burned—this promising plan and its apparatus were thrown aside as impracticable.

In the leisure hours of several years I succeeded in constructing and perfecting an apparatus and process which accomplished what the other processes failed to do with any practical degree of success—namely, the enamelling and moulding of the entire block at one process, this being the desideratum in carved work.

Substantially, the process consists in having movable matrices, corresponding in shape to the several teeth, for receiving the enamel, these matrices being fastened temporarily to the inside of the walls in proper position, when, after being filled with enamel, the body is moulded against them in the usual way.

More exactly described, these matrices or cusps for the reception of the enamel are made of very thin sheet brass, about No. 32, formed, or

Fig. 935.



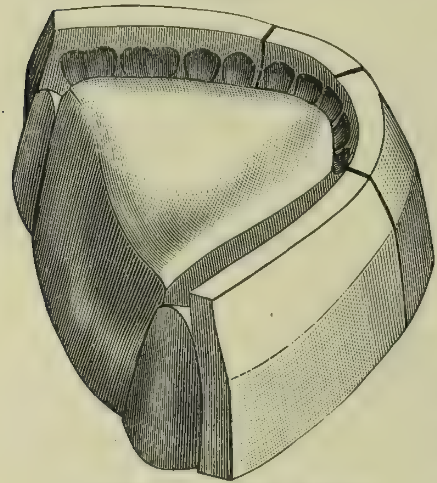
Enamel Cups.

rather stamped, over hard brass or steel dies: the die must be a perfectly-formed copy of the teeth wanted, and the stamping done with great care, so that the sheet brass may not be cut through. Figs. 935 and 936 show their form and mode of application better than any description.

These enamel cups, as I term them, are pressed into the articulating wax in the position required, and plaster walls are made over them in the usual way: when hard the walls are taken from the enamel cups

and wax and trimmed. The gum surface of the walls is lined with tin-foil, and the enamel cups are replaced and attached to the wall by a film of hot paraffin wax. When oiled they are ready to fill with enamel, the body being applied in the usual manner. To remove the walls, they are heated with the small flame of a spirit-lamp until the body is dry enough: this heat is sufficient to melt the paraffin that holds the cups and to allow the removal of the walls, leaving the cups on the block: each of the cups can now be removed without injury to the enamelled teeth.

Fig. 936.



The Same in Position for Moulding.

The difficulties of this plan are, chiefly, making the dies and enamel cups, and the very large number needed for a working set. In the beginning I made over one thousand, duplicate cups are so often wanted when the first are in use and to take the place of those lost or injured.

The advantages of the plan are—more perfect and finished teeth, their easy duplication, less liability to accidents, and the more solid, dense, and even distribution of the enamel. I use this process very frequently.

Furnaces, Muffles, Slides.

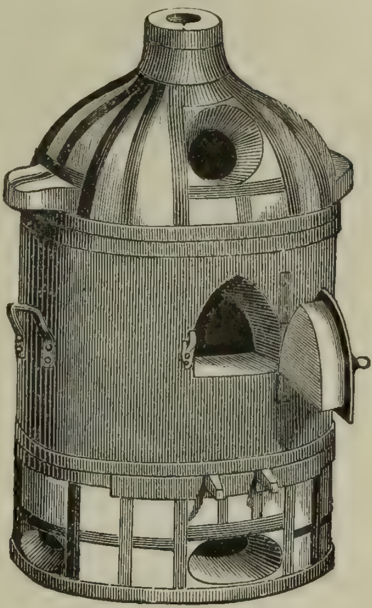
The manufacture of furnaces, muffles, and slides for burning teeth is a specialty of considerable importance. Extreme care is necessary in every part of the process to obtain the best material and just the right density of the muffle. Although they are made at the potteries, yet a general knowledge of the materials used, their combination, shaping, and firing, is very useful for ordering or selecting the finished articles. The fireclay for the slides and muffles has to be of the best quality, as free as possible from iron and spar. All clays contract very much when subjected to heat: to overcome this as much as possible, *burnt clay* is pounded into a coarse powder and mixed with fresh clay in proper proportions to form a plastic mass for moulding. After being burnt hard in a kiln the muffles are more or less porous: if the teeth are burned in such muffles, they will be discolored by the gases from the fuel leaking through and combining with the spar of the teeth; but this can be prevented by filling up the pores of the muffle before it is fastened in the furnace with kaolin mixed with water well rubbed in with a sponge, inside and outside, the rubbing to be repeated, when the muffle is cold, before every burning.

The best width for a muffle for block-work is three and a half inches, inside measure: frequent burning causes the muffle to sag, decreasing

the width, so that a slide two and a half inches in width is the best size to use. This is wide enough to hold eight carved blocks without crowding them too closely together for safety.

The furnace is oval in shape, the muffle occupying the shortest diameter, giving plenty of room for fuel at the sides. The height from the bottom to the top of the dome, not including the pipe extension, is thirty-two inches. The furnace is in three sections: the middle piece, holding the muffle, is fifteen inches high; the dome or top piece, eight inches high; the ash-pit or lower piece, holding the iron bars, nine inches high. The width or largest diameter of the middle piece is eighteen inches; the depth or shortest diameter, sixteen inches; the other sections correspond in diameter with the middle piece.

Fig. 937.



Furnace.

The door for the muffle is fastened to the sheet-iron casing of the middle piece, and swings by a riveted hinge: when closed a thumb-latch holds it during burning. All the sections are bound or encased with sheet-iron, as seen in the illustration.

The above furnace will hold sufficient coke to burn one slide of carved blocks. The burning heat lasts for half an hour if the coke is well packed. Coke lights and burns quickly, requiring prompt and quick movements of the workman to take advantage of the heat as it comes up.

The fire is made with small pieces of kindling-wood, laid on the iron bars in the lower piece and lighted with shavings from the ash-pit underneath: the coke must be added in small pieces the size of an egg, and packed together closely with a stout iron rod slightly bent in a curve at one end. When the coke burns rapidly it must be very solidly packed down under the muffle: the furnace must then be filled up and the coke well packed even with the pipehole at the top. Coke, being a light fuel, settles down quickly while burning.

A coal-fire is lighted in the same way, but requires very little packing, its weight causing the pieces to fall close enough to burn freely. The burning heat of coal lasts twice as long as coke, but is more destructive to the muffle: two or three slides can be burned with a coal-fire to one of coke.

A cooling muffle must be prepared to receive the blocks when taken from the muffle. It is one of the usual-sized muffles slipped into a sheet-iron casing, and is closed after the teeth are in it with the red-hot stopper of the fuel-hole in the dome.

The blocks when ready for burning are placed on a bed of very

coarse quartz about the size of gravel, which is laid in ridges for the better support of the blocks. Considerable judgment is necessary in laying the blocks, that the weight may be evenly distributed and not rest on any corner, as this will cause the block to warp. Neither must the quartz touch any of the enamel on the outside of the block, as this will cause a defect.

Burning.—The blocks after being placed on the slide must be thoroughly dried before they go into the muffle: putting a red-hot slide underneath them will dry them in eight or ten minutes. The slide is then grasped with a pair of long tongs, the ends of which are flattened for this purpose, the slide being at the same time supported with a thin iron bar held in the left hand. The slide is lifted gently and put in the middle of the muffle without jarring. When the vegetable matter is burned off, close the door if the heat of the muffle at this time should appear a little hazy: look at the teeth in about ten minutes. If the heat has been at the right point, they will appear partly fused and the enamel a little colored. Close the door and look again in three or four minutes: it is probable that at this time the teeth cannot be seen clearly on account of the increased haziness. Draw the slide quickly to the mouth of the muffle, and rapidly decide whether they are glazed enough: if not, return them, close the door, and look again in two or three minutes; if properly glazed, put them in the cooling muffle, which must be conveniently placed at the side of the furnace. Close the muffle tightly and leave the blocks undisturbed until entirely cold.

Porcelain-Base Dentures ("Mineral Plate Teeth").

Full dentures made entirely of porcelain in one continuous piece are claimed by some practitioners to be superior in many respects to all other styles of artificial teeth. Their advocates claim that they are of reasonable strength, notwithstanding the brittle nature of their composition; that they can be readily cleansed; that they have all the artistic merit resulting from carved teeth; while in their construction expensive metals, such as gold and platinum, are dispensed with.

These are advantages of considerable importance, and when the indications are favorable for this style of denture, such as sufficient space for enough material to give the requisite strength and proper curvature of the arch, it may be used; hence a knowledge of the manner of its construction will be of value.

There are several difficulties to be overcome in making an all-porcelain denture: The first is the moulding of so large a piece of porcelain material, covering the entire dental ridge, without cracking the body when it is dried firmly enough to carve; the second is in enlarging the cast to compensate for shrinkage of the body in burning; the third is the liability of accidents during the burning and cooling processes.

The most favorable cases for this form of denture are those in which the natural gums are very much absorbed, thus producing a flat palatine arch. This form affords room for sufficient body to give reasonable strength.

The following is the method the writer pursues in carving full upper sets: Two casts are taken from a plaster impression of the edentulous

upper jaw. A thin lead plate is then made to fit one of the casts by burnishing it down in every part. A piece of softened beeswax is then put on the ridge, and the articulation procured in the usual way: extra care must be taken to trim the wax to the exact fulness and height required. The cast and wax articulating model must then be enlarged to compensate for the contraction of the porcelain in burning: this contraction amounts, practically, to one-ninth of its bulk.

To make this enlargement the cast and articulation are with a thin saw divided into four sections. The first line of division is at the centre along the mesial line to the back of the cast; the second, across the cast just back of where the cuspid teeth are located. The wax articulation can be cut freely with a piece of fine wire.

Previous to this division the bottom of the cast must be made smooth and level: this is most easily done by pouring mixed plaster on a piece of window-glass and setting the cast on it, letting it remain until the plaster sets hard, then trimming the edges.

After the cast has been divided the sections are again placed on the piece of glass in such a manner as to leave between each of them a space of about a quarter of an inch: if in irregular cases more accuracy is desired, the proportional dividers should be used. The space must then be filled with freshly-mixed plaster, the sections being held in position by small pieces of wax. When the plaster becomes firm a new lead plate is cut, and by burnishing is made to fit accurately. The sections of the wax articulating model are placed on the enlarged cast, and the interspaces are filled with melted wax, thus making the model conform to the size of the enlarged cast.

An outside wall must then be made for moulding the body: this is done by bending a piece of tin round the front and sides of the cast (with the wax articulating model on it) to get the correct curve. The tin is then removed one-fourth of an inch from the cast in front and at the sides, and is sustained in this position until freshly-mixed plaster is poured into the space between the cast and tin. When this wall is trimmed it ought to reach one-fourth of an inch above the articulating wax, after the removal of which the wall should be lined with tin-foil. Both the cast and the wall are then made free from all small pieces of wax or plaster and perfectly cleansed for moulding.

The body is prepared as directed in the section on block carving, and is moulded on the lead plate made to fit the enlarged cast: the lead plate is used to facilitate the removal of the moulded set from the cast. The lead plate and inside of the wall should be oiled, and a piece of the body large enough for the purpose laid on the lead plate before the wall is put in place, and gently worked over the edge of the gum with the forefinger until it reaches the proper limit of the plate line. The wall is then put in place, and held firmly while the body is packed up against it as high as the top of the wall: the rest of the body is then pressed down to the surface of the lead plate, extending back as far as it is proposed to carry the plate. The body is then allowed to dry sufficiently to carve into shape. The wall is removed and the moulded set examined: if the body has split in drying, it can be repaired by working water into the fissure with a small carving knife. The moulded

piece should then be carved out roughly on the cast in the manner directed in the section on block carving. When roughly carved and reduced to nearly the proper thickness, the piece must be thoroughly dried and biscuit-baked in the furnace: all errors in the carving are then corrected. When the piece has been enamelled and the final carving and gumming completed, the set is dried, and is then ready for the muffle.

The burning of such large pieces of porcelain is more difficult than the burning of ordinary blocks: it is not admissible to draw the slide to the mouth of the muffle and return it again if not quite fully glazed, as this might crack the set. To determine the proper degree of glazing, small pieces of body with enamel on them are placed close to the set on the side near the mouth of the muffle: these may be pulled out with a hooked iron rod and examined. When removed from the furnace to the cooling muffle the set should not be allowed to remain in the open air a moment longer than is necessary to carry it thither. The muffle must be immediately closed with a hot stopper from the furnace. I have sometimes taken the extra precaution of covering the muffle with hot ashes to retard the cooling process.

The requisite care in adjusting the set on the slide for burning must not be omitted: the sagging of the palatine arch is of frequent occurrence if it is not properly supported. If the whole weight of the piece should rest on two or three points of the gum, it might result in serious warping. To provide against such a result, *clay supports* are moulded, upon which the piece of carved work rests and is sustained during the burning process. The formula for the composition of the support is—

Kaolin or white clay, 1 part;
Pulverized quartz, 2 parts.

Mix with sufficient water to form a mass plastic enough to mould in small pieces to the under side of the carved set.

Four small pieces made into balls are required—three in the groove directly under the teeth, the fourth under the palatine portion of the set. These balls are placed on a piece of glass in position for the teeth to be pressed firmly down on them, and are left undisturbed until the supports are dry enough to be safely removed. They are then to be surfaced with powdered quartz, and dried to be ready for use.

When the teeth are removed from the cooling muffle the set will require more or less grinding to fit the original cast, which, as will be remembered, was left unenlarged. This is accomplished with corundum wheels and points. To facilitate the grinding the prominent parts of the cast are coated with a mixture of rouge and oil, which will spot the under side of the set and show the exact place to be ground off to make the case fit solidly on the cast.

Very small corundum wheels and points are needed for grinding the more inaccessible places and for making small depressions for the rugæ, etc.: these wheels and points should be mounted on long thin mandrels, and be held either in the hand-piece of a dental engine or in a chuck that fits the grinding lathe.

With these appliances the successful result will depend upon the skill and judgment of the operator.

Porcelain Crowns.

In the last decade numerous forms of plain teeth have been invented for attachment to natural roots and for the various styles of bridge-work. The inventive genius of the dental profession seems almost to have exhausted all the possible forms and devices of this kind, and yet, so far, each one on a fair trial will show adaptability for some special service. Among those most used are the Bonwill, Gates-Bonwill, Weston, Foster, How, and Logan crowns. There are also dovetail and cusp crowns, veneers or facings, and cavity-stoppers. The latter are more or less delicately formed to meet the requirements of some special case, and as such are limited and confined to a narrow range of adaptation.

The teeth manufactured for continuous-gum and celluloid work and for rubber and fusible-alloy bases have a more extended area of application and are made in much more considerable quantities. The special qualities claimed for the above forms of teeth, in addition to those previously manufactured for plate- and rubber-work, are improvement in contour and security of attachment. These improvements have been very well carried out in continuous-gum teeth, and *not* so well in those for celluloid: the pins for attachment in the latter are frequently placed improperly, and often but one pin in a tooth; the pins are all placed too near the neck for strength; the laterals are especially liable to fracture during mastication.

By the arrangement of lateral pins shown in Figs. 938 and 939 the inventor, Dr. C. H. Land, claims that much greater strength is given to the completed denture than when teeth with the ordinary pins are used.

Fig. 938.

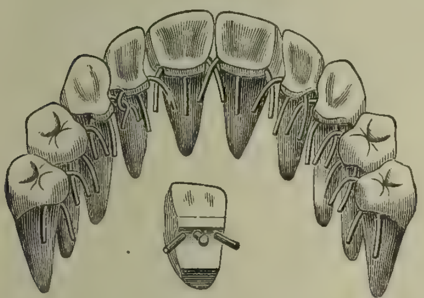
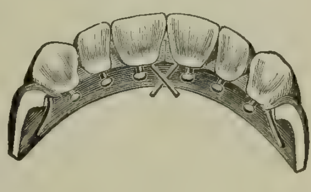


Fig. 939.



Countersunk Tooth-crowns.—The latest of the new forms seems to require a more particular description on account of its more extended usefulness and its possible greater demand. A denture of plain teeth on rubber or any other plastic base admits of great latitude in position of the teeth, enabling the artist to arrange them in every conceivable style from plain uniformity to extreme irregularity. One of the first to use countersunk crowns in connection with plastic bases was Dr. H. C. Register of Philadelphia.

Where the patient does not show more than two-thirds of the crown the countersunk teeth are capable of being arranged so as to produce

the most artistic effects, at the same time making a useful and serviceable denture. The lingual edge of the countersink should be ground away sufficiently to be on a level with the lingual surface of the plate, which will give greater strength to the plate and be of no injury to the teeth. The following are illustrations of the shape of these teeth and their special advantages as claimed by the manufactures:

FIG. 940.

"Properly mounted on celluloid or pink vulcanite, they form dentures which fairly rival continuous-gum work in naturalness of appearance, without the objectionable weight of the latter.

"Their close conformity in contour to the natural organs makes them much more acceptable to the tongue than teeth backed in the ordinary manner, renders articulation easier and more distinct, and prevents disclosure of artificiality when the mouth is opened. In addition to these manifest and great advantages, these new crowns allow of greater facility of adaptation to the maxillary ridge, and the denture when completed is the strongest that has yet been made on a plastic base.

"To ensure the best results some precaution is necessary in mounting them, whether on rubber, celluloid, or metal.

"For a vulcanite base the case should be flasked as usual, but each countersink should be carefully filled with small pieces of rubber, otherwise the flat rubber sheet will cover the mouths of the countersinks, and so shut in the air as to prevent the rubber from reaching the pins and filling the cavities.

"When the base is of celluloid the countersinks must be filled in like manner with pieces of celluloid moistened with spirit of camphor—or preferably with a solution of celluloid—and the case heated to softness before closing the flask.

"For a fusible-metal base the hot flask should be jarred during the pouring to drive the air out of the countersinks."

In view of the slight and delicate edges of some of these crowns they certainly require greater strength than that furnished by the composi-

tions ordinarily employed in the manufacture of porcelain teeth. On this account I would propose a slight decrease in the proportion of feldspar to obtain additional strength, suggesting this formula for the body-composition:

Feldspar,	13	oz.
Quartz,	3	"
German clay,	$\frac{1}{2}$	"

The above materials should be prepared and combined as directed in the remarks on the composition of body.

English teeth, manufactured by Ash & Sons, have several characteristics desirable for special cases: the main ones are their beautiful coloring and soft translucency, which admirably adapt them for matching natural teeth. It is to be regretted that the teeth recently manufactured are not so beautifully colored as those formerly made: their old style of tube teeth had the perfection of coloring and could not be excelled. The texture of the body appears as fine as the enamel, and just as transparent throughout, suggesting the idea of easy fracture. My personal experience in practice with them has not been sufficient to determine this point. The teeth are all plain, with long platinum pins, suitable for the several styles of plate, rubber, bridge, and crown work.

Burning these small pieces of porcelain is attended with greater risk than is the burning of the larger-sized teeth: they vitrify in less time, and the shape is more liable to injury than the larger-sized when subjected to the usual burning heat of the furnace.

To avoid disasters from over-burning it is prudent to separate the small from the large teeth, arranging them on slides that can be placed in the muffle at the most appropriate heat, which is preferably at the beginning or close of the burning process. The intermediate or more intense heat, being the most suitable for blocks and large work, is reserved for that purpose: this routine, together with the preparatory heating of the slides in the upper muffle, will fairly economize all the heat of the furnace.

THE HYGIENIC RELATIONS OF ARTIFICIAL DENTURES.

By EDWARD C. KIRK, D. D. S.

In view of the large number of individuals who by reason of premature loss of the natural dental organs are compelled to wear artificial substitutes, and the prevalence of various morbid or pathological conditions which arise from the wearing of artificial dentures, it is of the greatest importance that the deleterious influences which such appliances often exert should be recognized and eliminated as fully as possible in each instance.

The hygienic relations of artificial dentures may be classed as local and systemic. Under the first division by far the largest number of morbid phenomena consequent upon their use are observed, although instances of marked constitutional disturbance have been traced to the wearing of artificial dentures where, by reason of maladaptation or of unsuitable material used in their construction, the appliance has set up and maintained an amount of local irritation sufficient to produce unmistakable systemic derangement.

It should be borne in mind in all instances that in inserting an artificial denture, of whatever character, a foreign body is introduced into the oral cavity which under certain circumstances may act in greater or less degree as an irritant to tissues or organs with which it comes in contact; hence a careful study should be made of all the conditions in each case, so that the irritative action which so often follows its constant presence and use may be reduced to a minimum.

As loss of the natural teeth is the condition which calls for prosthetic treatment, it will be necessary to consider—First, the insertion of partial dentures and the health of the mouth and remaining teeth as related to the various methods in vogue for accomplishing this purpose; and second, the health of edentulous mouths in relation to the several methods of replacement by entire artificial dentures.

Partial dentures are retained *in situ* by atmospheric pressure, by clasps, or by permanent attachment to natural teeth or roots.

Excluding for the present any consideration of the effects produced by the various materials used in the construction of artificial work, the hygienic condition of the mouth and teeth fitted with a partial artificial denture maintained in position by atmospheric pressure will depend upon the accuracy of its adaptation and the care exercised by the patient in securing absolute cleanliness of both the mouth and plate.

Want of proper adaptation may become a source of irritation produc-

tive of an amount of morbid activity varying in degree from a simple reddening and chronic inflammation of the tissues, without hypertrophy, to the production of malignant growths. Rough surfaces, projecting edges or points, want of careful fitting of the plate around the necks of remaining natural teeth, unequally-distributed pressure upon localized portions of the hard palate, causing as it does the plate to rock during mastication,—are fruitful sources of irritation which may result in the loss of the remaining teeth or bring about inflammatory action either chronic or acute, frequently resulting on the one hand in rapid absorption of the underlying osseous structures, with hypertrophy of the mucous membrane and gum-tissue, or on the other in suppuration and abscess, with sloughing of the soft parts. A frequent sequel to the use of an ill-fitting denture is dyspepsia and the train of systemic disorders produced by improper digestion of food, owing to the fact that the patient is unable to masticate it properly, and either bolts it or abstains from eating a sufficient quantity of nourishing diet because of the difficulty or annoyance experienced in masticating it. In all disorders involving the digestive function the condition of the mouth and teeth should be investigated to ascertain if the masticatory apparatus is capable of fully accomplishing the duty required of it; and if found imperfect the proper treatment to correct the defect should be instituted, as instances constantly occur where the digestive function, though greatly impaired, has been restored to its normal condition by such a course.

Lack of cleanliness in the care of an artificial denture, but particularly in a badly-fitted one, is a fruitful cause of inflammatory conditions. Débris of food, mixed with saliva and mucus, forms a mass which, if not promptly and thoroughly removed from the plate, undergoes fermentation and decomposition with great rapidity, with the result of irritating the mucous membrane and producing a general inflammation of the oral cavity. The oral secretions become altered and vitiated to an extent sufficient to cause derangement of the digestive function, and the whole alimentary tract may become irritated, giving rise to dyspepsia or chronic diarrhœa. Under such conditions caries of the remaining natural teeth proceeds with great rapidity, particularly upon their proximal surfaces; the gums recede, and the cementum, especially upon the surfaces in contact with the plate, becomes softened and carious. Care in cleansing a partial artificial denture is of the utmost importance; the cleansing should be performed immediately after eating, and particularly before retiring for the night, in order that the tissues of the mouth, and especially the teeth that remain, may be maintained in a perfectly healthy condition.

The addition of clasps to a partial artificial denture introduces an element affecting more or less the integrity of the remaining natural teeth, but is without influence upon the other tissues of the oral cavity, except in so far as they are affected secondarily through diseased conditions of the teeth caused by the clasping. Generally, the result produced by clasping a natural tooth is the loss of its structure, either through caries, mechanical abrasion, electro-chemical action, or by the joint action of all the foregoing causes.

The rapidity with which the disintegrating process advances is largely

determined by the quality of the tooth-structure, the condition of the oral fluids, the size and form of the clasp, the portion of the tooth which is embraced by it, and the material of which the clasp is constructed. Badly-fitted clasps bring about rapid loss of tooth-structure, from the fact that food and the oral fluids which find a lodging-place between the tooth and clasp rapidly undergo decomposition, and the products of fermentation attack the tooth-structure.

A loosely-fitted clasp from motion of the plate during mastication wears away the surface mechanically. Clasps, particularly when made narrow, or fitted closely against the free margin of the gum, cause recession of that tissue and exposure of the cementum, which is in nearly all instances softened after a time by caries, this extending even to the pulp. This result is frequently noticed in the palatine roots of superior molars which have been clasped. Absorption of the alveolus may take place also, with extrusion of the tooth till it finally falls from its socket.

Experience has demonstrated that clasps should be used only as a last resort, owing to their injurious action upon the teeth; and in order to secure the best results from a mechanical as well as a hygienic standpoint they should be as broad as practicable, accurately fitted, embrace the teeth firmly at their most convex portions, and not impinge upon the necks or reach to the free margin of the gum.

The result of careful observation tends to show that clasps exert an influence upon teeth varying in degree according to the condition of the oral fluids or the kind of metal of which the clasp is made. Thus, a denture constructed of coin silver with clasps of the same metal exerts a more rapid disintegrating influence than one made of coin silver fitted with gold clasps; or, again, a plate of vulcanite with clasps made from platinum or iridio-platinum alloy acts more injuriously than the same appliance fitted with gold clasps. These facts, with others which will be alluded to hereafter, tend to show the existence under certain conditions of the oral secretions of a galvanic current between the tooth-structure clasped and the metal forming the plate. In fact, in the present condition of our knowledge of the subject, these and several other phenomena observed in the mouths of patients wearing plates of this character are only explainable upon the electro-chemical hypothesis. In the case of a partial denture of silver with clasps of the same metal it is believed that the negative element is represented by the plate, while the tooth forms the positive; under which conditions disintegration of tooth-substance would proceed rapidly if the neutrality of the saliva should at any time be disturbed. When caries has proceeded under a clasp to such an extent that filling becomes necessary, it is a well-known fact that a properly-inserted amalgam filling will almost certainly arrest the further progress of the disintegration, while a gold filling equally well inserted is likely to prove a failure; which is explained on the ground that the electro-chemical action in this case is confined to the metals of the plate and the alloy, which latter rapidly becomes black, the tooth being thrown out of the circuit. A case has been reported to the author where a partial lower denture of gold was fitted in the mouth of a patient by clasps, but upon slight motion of the plate a distinct galvanic shock was experienced, causing so much annoyance that it became intolerable. Upon

reporting to his dentist, the difficulty was entirely removed by simply amalgamating the sides of the clasps that impinged upon the teeth: a closed circuit was thus made between the clasp and the mercury on its surface. The saliva in this case was distinctly acid in its reaction.

Gold clasps used upon silver plates greatly modify, if they do not entirely neutralize, any tendency to the production of a current, limiting the galvanic action, if there be any, to the plate and clasps by forming a closed circuit, excluding any action of an electrical character upon the tooth clasped.

Platinum and iridium-platinum alloy exert an eroding influence upon dental structure in certain conditions of the oral fluids, in a marked degree differing materially in the manner of their action from any of the other metals. The surface acted upon by these metals is removed rapidly without previous softening, the teeth presenting much the same appearance as those affected by the condition known as erosion of the enamel: the eroded parts generally are polished, though when broad clasps have been used the surface is often more or less rough. The effect of the continued contact of platinum with tooth-structure is abundantly illustrated where it has been used in the form of fine wire as a permanent ligature to retain teeth in position for any length of time after regulating; for which purpose, by reason of its softness, it is particularly well adapted; but its positively injurious effect, often cutting deep grooves in the enamel in a remarkably short time, entirely precludes its use in such cases.

Plates with clasps attached should under no circumstances be worn at night. It has been demonstrated by careful observation that the oral secretions at night tend to become slightly acid in many individuals, apart from the result of fermentation of food-particles, owing no doubt to the fact that the more or less acid secretion from the mucus-follicles is not neutralized by the alkaline saliva as during the day, salivary secretions being almost entirely suppressed during sleep. In patients subject to enamel erosion a careful testing of the oral secretion with litmus immediately after waking and before the salivary secretion has started has shown this to be the case. Patients of the gouty diathesis and chronic sufferers from rheumatism show the same condition in a marked degree, as well as those who are victims of dyspepsia. In any condition of the system which tends to create an acid condition of the oral fluids the most scrupulous care must be exercised in cleansing a partial artificial denture worn under such circumstances, as well as the remaining natural teeth, and an alkaline wash of lime-water or sodium bicarbonate should be used frequently for rinsing the mouth. If sensitiveness exists about the necks of the teeth, or a tendency to softening or erosion of the tooth-structure, the plate should be examined in the mouth to see if any undue pressure is exerted upon the teeth; and if such is the case it should be corrected, after which the patient should be directed to remove the plate each night before retiring and rub a small quantity of precipitated chalk, made into a thick paste with water, around and between the affected teeth.

Partial artificial dentures permanently attached to one or more natural teeth may be taken to include the grafting of a single artificial crown on

a healthy root or the attachment of several crowns to one or more roots, known as bridge-work. The first operation presents no features which affect the integrity of any of the tissues beyond that of the root operated upon: the substitution of an artificial crown for a natural one on a healthy root in no wise affects the health of such a root, provided it has been skilfully done, and a root so treated is to be viewed from a physiological standpoint, as being in the same condition as a tooth with a natural crown in which the pulp has been devitalized and the pulp-chamber and canals, together with the cavity of decay, thoroughly and properly filled: such a tooth is subject to the same danger of pericemental inflammation and abscess with its sequelæ, but in no greater degree.

The grafting of crowns upon healthy roots is a conservative operation which by the simple fact of restoring the occlusion and bringing them in service tends to prolong their retention in the mouth, whereas if they were left without crowns they would eventually be extruded from their alveoli and lost. In the so-called bridging of interdental spaces by several crowns fastened together and attached to contiguous natural teeth or roots the danger of pathological conditions increases in proportion to the extent of the operation, and is greatly modified by the exactness and care with which it is done. Such operations when extensive in character present two fruitful sources of difficulty: First, two or more roots are required to perform an amount of work many times greater than they were originally called upon to do, by reason of which they are subjected to a degree of strain which may lead to their fracture, or, as more frequently happens, to congestion and chronic inflammation of their pericemental membranes, resulting in abscess or continued soreness, thereby rendering mastication painful and imperfect.

But by far the greatest and most potent argument against this class of work is the impossibility of keeping the appliance thoroughly clean, though much depends upon the extent of the operation and the method pursued in its construction and attachment. Cases have occurred where by reason of the irritation set up by the impaction of food-débris and fermenting secretions between the gum-tissue and band to which the crowns were attached the mucous membrane has become greatly hypertrophied, so that the appliance was imbedded to half its depth, and the secretions of the mouth and breath of the patient rendered foul and vitiated. On the other hand, rapid absorption of the alveolar ridge may occur, leaving a wide space between the denture and gum, affording a trap for food difficult to cleanse.

It is doubtful whether extensive operations of this class, considered from a hygienic standpoint, are as satisfactory as a properly-constructed artificial denture maintained in position by atmospheric pressure, owing to the impossibility of their removal by the patient for the purpose of cleansing, and the inability to do so thoroughly in the mouth.

The materials used in the construction of artificial dentures differ widely in their effect upon the tissues with which they come in contact. Of the cases of oral irritation associated with or due to the wearing of artificial dentures, excluding those resulting from lack of cleanliness—which is a cause sufficient to produce local oral inflammation under any denture, without regard to the material of which it is made—by far the

greater proportionate number result from the wearing of dentures made upon the vegetable—*i. e.* vulcanite or celluloid—bases. So prevalent is this inflammatory condition, and so generally associated with the wearing of vulcanite plates, that it has received the distinctive appellation of "rubber sore mouth." The trouble is characterized in its early stages by redness of the mucous membrane, circumscribed in extent and limited to the area covered by the plate; slight puffiness of the tissues, sometimes with exalted sensibility of the affected parts amounting to tenderness; a feeling of heat under the plate; and more or less fetor of the breath. A close examination of the inflamed mucous membrane reveals the existence of minute intensely red points closely dotted over its surface. Under these conditions absorption of the alveolar ridge progresses with great rapidity, the denture eventually becoming loose and useless for mastication. During the chronic stage of rubber sore mouth the tissues are subject to exacerbations of an acute type of inflammation, which may extend to the tonsils and walls of the pharynx; the parts underlying the denture become greatly swollen and painful, rendering the wearing of the plate impossible for the time. The inflammatory action may result in the formation of an abscess, or under appropriate treatment resolution may take place without the production of pus. The acute inflammatory attacks generally come on suddenly and without any cause apparent to the patient, who usually attributes them to cold. They are probably produced by wearing an ill-fitting plate, the maladaptation being due to absorption of the ridge caused by the irritating qualities of the denture, thus introducing another potent cause of inflammatory action, especially where the mouth has been for some time in a chronically inflamed condition.

Local antiphlogistic treatment at the onset is of great service in preventing the further progress of the inflammation: crushed ice held in the mouth affords grateful relief from the heat and pain of the parts, and may be all that is necessary. Should this fail, free depletion of the parts by scarification—or, better, by leeches—should be resorted to, after which the persistent use of phénol sodique, diluted in the proportion of two tablespoonfuls to a tumbler of water, is almost certain to effect a cure, or an astringent wash of tannic acid and glycerin, with borax or potassium chlorate, may be used. The following formula gives good results:

℞.	Glycerit. acid. tannic.,	f℥ss;
	Potass. chlorat.,	ʒj;
	Aq. rosæ,	f℥vj. M.

This is to be diluted with equal proportions of water and used frequently to rinse the mouth.

The chronic stage of rubber sore mouth is curable only by the removal of its obvious cause and the substitution of a denture made upon metal, preferably gold or platinum.

Absorption of the alveolar ridge often proceeds to such an extent that the hard palate becomes not only flat, but the soft tissues may so overhang the ridge that depressions will exist in positions originally occupied by the ridge. This happens, however, only in extreme cases:

under such circumstances the greatest difficulty is experienced in retaining a denture by atmospheric pressure, making in some cases a resort to spiral springs necessary as a means of retention. Aside from its positively irritating qualities in many instances, the rapid absorption of the alveolar ridge under rubber plates necessitates their frequent remodelling or renewal, and the plate necessarily becomes bulkier and heavier as the ability of the patient to retain it in the mouth grows less.

Several reasons are assigned for the effects caused by vulcanite: viz. the specific poisonous action of the vermilion used in it as a pigment; its non-conducting qualities for heat; imperfect vulcanization, causing porosity of the plate, which absorbs the secretions, these by decomposition resulting in irritating substances which produce the condition; or to the growth of micro-organisms upon the surface of the plate in contact with the palatine mucous membrane, these organisms secreting an acid fluid which exerts an irritant action upon the tissues with which it is held in contact by the plate.

As nearly all the vulcanizable rubber used in the construction of artificial dentures is of the red variety, which owes its color to mercuric sulphide or vermilion, many have looked upon it as the sole cause of the annoying condition under consideration. Many cases in practice tend to a confirmation of this idea, yet a careful analysis of them, as well as the absence of conclusive evidence based upon systematic scientific investigation, fails as yet to establish the truth of such a theory. The conclusion has been jumped at that as vermilion is a salt of mercury, its action must necessarily be poisonous. That such is not the case is evident from the fact that it is wholly inert medicinally, and is one of the most insoluble of the mercurial salts. With the exception of a strong solution of sodium sulphide there is no menstruum that will dissolve it which will represent a solution of mercuric sulphide, and it is only decomposable by heat or the strong mineral acids. It has been asserted that under the conditions to which it is subjected in producing a dental plate decomposition of the vermilion sometimes takes place, resulting in the liberation upon the surface and throughout the texture of the plate of metallic mercury, which, being acted upon by the oral fluids, produces local mercurial poisoning. While it may be possible that individual samples have been shown to contain free metallic mercury, a study of all the conditions would preclude, theoretically at least, the possibility of such a general occurrence of it as to account for the frequency of rubber sore mouth. The temperature to which the vermilion is subjected during vulcanization is far below that necessary to effect its decomposition, and even should the proper temperature be reached accidentally, the presence of sulphur incorporated with the material in great excess, which is necessary to effect the hardening of the rubber, would immediately reconvert into mercuric sulphide any mercury which had been set free. Cases are frequently cited in support of the asserted poisonous effects of vermilion where the substitution of black rubber for red has overcome the tendency to sore mouth. That this procedure often fails to relieve the difficulty is abundantly proven, though black rubber is an evident improvement upon the red variety so far as the health of the tissues of the mouth are con-

cerned, it being composed only of pure caoutchouc and sulphur, without the addition of any mineral coloring matter: the texture of the finished piece is therefore finer, more dense, and less spongy, consequently less liable to absorb and retain the secretions.

Vulcanite plates, of whatever composition, insufficiently hardened or carelessly vulcanized, yielding a plate which has not a fine, dense texture, but open-grained or porous, more especially if the surface is not carefully and smoothly finished, almost invariably irritate the mucous membrane, producing a characteristic rubber sore mouth, the surface of the plate in time assuming a corroded appearance. This result is frequently seen in dentures which have rims made from soft or so-called palate rubber. The tissue in contact with the soft rim will often be highly inflamed, while that under the hard, highly-polished portion of the plate will present a healthy appearance.

Dr. G. V. Black asserts[1] that the sore mouth produced by artificial dentures is due to the growth of certain fungi, the Streptococcus magnus, S. continuosum, etc., which elaborate an acid secretion that acts as an irritant to the mucous membrane and causes the condition. He finds these fungi upon the surface of all plates, without regard to the material of which they are constructed, but in greatest number upon the surface of vulcanite dentures; which he attributes to the fact that the irregularities and roughnesses of the surfaces of such plates afford lodging-places where they rapidly develop, because the plate cannot be as readily kept clean. He regards absolute cleanliness as a complete protection from inflammation.

Repeated tests of the mucous secretion of the inflamed membrane, made by the author, in cases of rubber sore mouth have, however, generally shown an alkaline reaction of the mucus as it was eliminated. This condition of alkalinity has been so constant in the cases observed that it has suggested the possibility that alkaline sulphides might be eliminated to a sufficient extent to exert a slight solvent action upon the mercuric sulphide of the plate. Rubber sore mouth is accountable for upon so many other and more reasonable grounds than that of mercurial action, and especially because it occurs under plates of all kinds when cleanliness is not observed, that the mercurial-poisoning theory would seem to be erroneous, though that mercurial action is to some extent a factor in the production of local irritation under red vulcanite dentures is by no means disproven, and the effect of alkaline mucus upon the mercurial pigment in red vulcanite plates presents an interesting field of investigation which may shed much light upon the question in future.

In addition to the above causes, the non-conducting quality of vulcanite undoubtedly plays an important part in the production of this kind of inflammatory action. The effect on the tissues continually enclosed by the non-conducting plate is to maintain a hyperæmic condition, with slight increase of temperature; this in addition to the pressure, which, if it does not result in inflammation, is a source of irritation sufficiently active to bring about greatly increased functional activity of the cells of the parts, resulting in rapid absorption of the

[1] *Transactions of the Illinois State Dental Society*, 1886, p. 188.

underlying osseous structures or hypertrophy of the gum-tissues generally. If the wearing of black vulcanite did not bring about the same inflammation of the tissues, the vermilion theory would have more force; but as all the vegetable bases are open to the same objection, it is highly probable that their non-conducting properties are in the main responsible for their irritating action in sensitive or tender mouths. Too much care cannot be given to the finish of the surface that comes in contact with the tissues of the mouth. The upper surface of a plate, if rough, almost invariably brings about inflammatory action in a short time.

Celluloid is open to the same objection, though, as now manipulated upon tin dies or casts covered with tin-foil, perhaps in a less degree, as the surface presented to the tissues is dense, highly polished, and free from roughness. It is a slightly better conductor of heat, but the plates produced are subject to greater variations in texture, resulting from the different processes of manipulating it, some being dense, while others are quite spongy.

That much of the inflammation observed under plates made upon the vegetable bases is due to roughness and porosity of the plate is shown by a case in the practice of the writer where a lady patient was suffering from a typical case of the so-called rubber sore mouth from wearing a plate, the only one she had ever worn, made of celluloid, which was rough and porous. The difficulty was entirely relieved by the use of astringent washes for a short time and the substitution of a properly-finished denture made of red vulcanite. Irregular absorption of the alveolar ridge with circumscribed irritation and hypertrophy of the soft parts is often observed in mouths where the force of the occluding teeth is not evenly distributed over the whole denture, as in mouths fitted with an entire upper denture where only the oral teeth of the lower jaw remain. This brings the force of mastication unduly upon the anterior portion of the superior alveolar ridge, which results in a rapid absorption of that part of the ridge, while the posterior portions remain well developed and healthy. This condition should always be prevented by inserting a partial lower piece which will throw the force of mastication upon the bicuspids and molars.

Hygienically considered, the vegetable bases bear no comparison with the metals used for artificial dentures. For partial work gold stands unequalled and answers every requirement, assuming that the plate is conscientiously kept clean by the patient and that the quality of the metal is not debased to an undue extent by alloying. While gold plate of eighteen-carat standard is most generally used, it is asserted that there are some mouths which will not tolerate without irritation a plate below the fineness of twenty carats. Instances of sore mouth caused by gold plates are extremely rare, and are usually traceable to one of two causes—either maladaptation or lack of cleanliness: in each instance the remedy is obvious. Silver, while free from many of the objectionable qualities of the vegetable bases, presents one feature which renders it unsuitable in the majority of cases as a base—namely, the strong affinity which it has for sulphur and many of its compounds. In most mouths silver plates rapidly tarnish, and are slowly corroded by the formation of silver sulphide upon the surface. This action can be

retarded greatly by largely alloying the the silver with platinum, but even then it is not entirely overcome: the plate after having been worn presents an uncleanly appearance, and, besides having a disagreeable metallic taste, often gives a decided fetor to the breath.

The tendency to corrosion of silver plates by sulphur has been practically overcome by a method of preparation of the metal recently introduced in England. In a general way, the process consists of making an alloy of platinum and silver, which, after being cast into an ingot and rolled down to about twice the thickness required, is subjected to the action of nitric or hot sulphuric acid, which removes all the silver from the surface of the metal, after which it is rolled down once more to condense the platinum, and is again treated with the acid: after this it is rolled to the proper thickness. The result is a plate having a core composed of silver and platinum alloy and a pure platinum surface, which is not affected by the fluids of the mouth in any manner.

For full dentures the continuous-gum method on platinum of Dr. John Allen undoubtedly occupies first rank. By it all the objections urged against the vegetable bases are overcome, and a mouth which will bear the contact of any artificial denture will not be irritated by one of continuous gum accurately fitted and kept clean. Whatever objections may be entertained against it from a mechanical standpoint, it is certain that all the hygienic as well as artistic requirements of an artificial substitute for the lost dental organs are fulfilled by this process. It is a sufficiently good conductor of heat; the materials of which it is made are absolutely unalterable in the mouth; its freedom from joints or crevices to act as lodging-places for food-particles and secretions permits of its thorough and ready cleansing; and, being highly polished on all of its surfaces, it is absolutely free from all roughness.

Materials other than those already alluded to have been used for the construction of dental plates—viz. aluminum, palladium, porcelain, etc. —but their use has been extremely limited, owing to the difficulties encountered in their construction and the lack of special advantages sufficient to enable them to supplant those already in practical use: a discussion of their individual hygienic merits would therefore be superfluous.

Great diversity of opinion appears to exist as to the advisability of wearing artificial dentures at night during sleep. The habit is easily acquired, and soon becomes so fixed that to many individuals the mouth is positively uncomfortable without a plate, especially those who wear entire upper and lower dentures. The inferior maxilla having no fixed resting-point from the absence of its accustomed support, the muscles which control it become fatigued from want of the proper relaxation and rest which sleep produces. Many also claim that better adaptation is maintained when the plate is constantly worn. It cannot be denied, however, that so far as the health of the tissues of the mouth is concerned, and the integrity of the remaining natural teeth in the case of partial dentures, the practice of wearing a plate continuously day and night increases the danger of pathological conditions in a great degree, and that the mouths which present the healthiest appearance,

especially those fitted with dentures upon the vegetable bases, are those which are only subjected to the contact of the plate for the shortest possible time, and are wholly free from it during sleep.

The method of retention of upper plates *in situ* by atmospheric pressure presents some important points having a direct bearing upon the hygienic relations of dentures constructed upon that plan. It is not necessary in all cases of full upper replacement that the vacuum-chamber should be resorted to in order to secure firm adhesion of the plate. Where the vacuum-chamber is dispensed with, complete adhesion is readily obtained in many cases by causing the plate to embrace the alveolar ridge as high as possible upon its labial and buccal aspects, and bringing the pressure to bear principally upon the softer and thicker portions of the ridge and hard palate, and relieving it upon the hard and bony portions of the ridge and palate by a method to be alluded to subsequently.

The vacuum-chamber is used to secure adhesion in partial upper plates and in many entire upper dentures which do not adhere properly without it. The principle of the vacuum-chamber is sufficiently simple. The atmospheric pressure, which amounts in round numbers to fifteen pounds per square inch, is exerted in all directions equally upon the tissues of the body, and as long as the equilibrium of pressure is maintained it is not evident to our senses. By removing the pressure from any portion of the surface by an exhaust-pump or as in the familiar operation of dry cupping the effect of the atmospheric pressure is made evident, the equilibrium is destroyed and the tissues are forcibly driven into the vacuum created. The effect of a denture having a vacuum-chamber and maintained in position by atmospheric pressure is exactly similar in principle to the action of a cupping-glass. The equilibrium of the atmospheric pressure is destroyed by exhausting the air from the vacuum-chamber of the plate: the pressure immediately manifests itself by firm adhesion of the plate to the tissues of the hard palate. The plate, being composed of an unyielding and rigid material, sustains the weight of the atmosphere exerted upon it; but the soft tissues covering the hard palate, being elastic, are forcibly driven down into the vacuum-chamber until they after a time completely fill it. The tissue which is driven into the chamber frequently becomes hypertrophied and inflamed: this is particularly the case where the chamber is large and deep or is

FIG. 941.

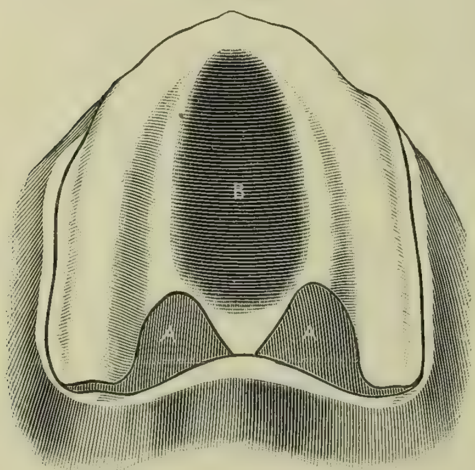
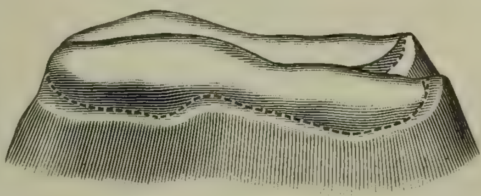


Diagram of cast prepared for making plate without the vacuum-chamber, from cast furnished by Dr. L. P. Haskell.

of the form known as the Cleveland chamber. Instances are not wanting where the tissues have presented a condition of chronic inflammation strongly suggestive of that seen in morbid growths of a malignant type. The deleterious effects in some instances of improperly constructed vacuum-chambers, and their questionable utility after the tissues completely fill the cavity in the plate, have suggested the advisability of dispensing with them altogether in full upper dentures, and so forming the plate as to bring all the pressure to bear upon the thicker and softer portions of the hard palate and alveolar ridge. The method pursued by Dr. L. P. Haskell and others is to scrape the cast at the points A, A (see Fig. 941), where the tissues are generally thick and yielding, and build a thin layer of wax upon the central portion, B, of the cast, which represents the part where the bony ridge or symphysis of the palatine processes of the superior maxillary bones is but thinly covered with tissue. Such treatment throws greater pressure upon the alveolar ridge, and the plate is less liable to rock or tilt during mastication. Dr. Haskell insists that the plate should be worn as high as possible, especially over the position of the cuspids (Fig. 942); by which means he asserts that the plate is rendered firmer and the contour of the lip can be more accurately restored.

FIG. 942.



Side view of cast, from Dr. Haskell, showing height to which the rim of the plate is carried.

Of course in cases where the tissues over the entire palate are yielding the addition of wax to the palatine portion of the model is unnecessary.

Where, as in the majority of cases, resort to the vacuum-chamber is necessary, it should be made as shallow as possible, and embrace considerable area, rather than be made deep and small in superficial extent.

DENTAL AND FACIAL TYPES.

By ROBERT S. IVY, D. D. S.

The difference between man and man in respect to dental and facial appearances has, by various observers, been attributed to a variety of causes and influences. Among these temperament and racial characteristics have been the bases upon which classifications have been formed.

It has been questioned whether the classification of individuals according to temperament is in practice worthy of the importance that some writers assume for it, the substitute offered being a classification by race as more permanent and practicable. The various characteristics embodied in the following pages and attributed to temperament are, however, not without some value under certain conditions; but it must be admitted that the classification of mankind into a number of permanent varieties or races is based on grounds much more definite.

Amongst the principal racial characteristics the color of the skin is specially distinctive, various races being accordingly described as white, yellow, brown, or black, these colors being graded from the fair hue of the Swede and darker tint of the Provençal to the withered-leaf brown of the Hottentot, the chocolate brown of the Mexican, and the brown-black of the West African. The arrangement and structure of the hair are also distinctive of race, it varying from scantiness to profusion upon the bodies of individuals in different races; and its equal distribution upon the head of the European is in strong contrast to the tufts seen on that of the Bushman. The frizzed hair of the negro also shows a marked difference from that of the long straight hair of the North American or Malay, both varying from the waving or curling hair of the European.

The shape of the skull and the important part it plays in giving general contour to the face are specially distinctive from their variation in different races, the prominent cheek (malar) bones of the Japanese and of the American Indian being illustrative of this. The position of the jaws is recognized also as important, races being described as prognathous when the jaws project as in the Australian or Negro, in contradistinction to the orthognathous type as seen in the European.

These and other variations, however definite they may appear to be, are possibly of little more value from a pathological standpoint than the grouping by temperaments, as race characters from crossing and constant intermixture, also from the climatic influence on the color of the same race in different countries, present wide deviations from a standard. This is instanced in the case of the Jewish race. In the north

of Europe, Jews are fair and have red beards and blue eyes; in their original country they are tawny; traced still farther in a south-easterly direction, they are deep brown; and in Malabar they are almost black.

In seeking for something fundamental upon which to form a classification of temperaments, Dr. Hutchinson (from whose lectures much information on this subject is derived) says: "Are we not obliged to confess that we have but little to guide us in a classification excepting the conditions which go to make up what we mean by complexion? In complexion we include the color of the hair and eyes, the state of the skin as regards thickness, thinness, or transparency, and the various degrees of freedom of distribution of blood in the capillaries of the face. It is easy to apply with tolerable accuracy such words as blonde, fair, dark, brunette, sallow, pale, florid, clear, muddy, and the like, and these and many others are epithets applicable to the complexion. Temperament, however, although to a large extent confessedly indicated by complexion, is generally held to include something more. If it did not, I fear we should find it but a sorry basis upon which to build a knowledge of the vital peculiarities of the individual. Yet, again, I ask, What have we to which we can make appeal? We may examine a man's features, note the size of his bones, the shape of his jaws, the brilliancy of his eye, the coarseness or fineness of his hair, his stature, his muscularity, his abundance or otherwise of cellular tissue and fat; but in observing all these things we shall be reminded that some of them are simply peculiarities of family or of race, and have little or nothing to do with health, whilst others are conditions which may vary much at different periods during the same life."

Temperament, diathesis, and idiosyncrasy are frequently used as synonymous terms, whereas each has a separate and distinct meaning and application. Temperament concerns only the original organization of individuals. Different temperaments when most strongly marked will doubtless give some special feature to an unhealthy condition brought about by other causes, but they do not in themselves comprehend any peculiar tendency to disease, consequently are perfectly in keeping with a healthy condition. Diathesis, on the contrary, may be inherited or acquired, the term implying a predisposition to certain diseases—"any bodily condition, however induced, in virtue of which the individual, through a long period or usually through the whole life, is prone to suffer from some peculiar type of disease."

A further distinction between temperament and diathesis may be drawn, as the one refers to a physiological condition as a part of the primary construction of the individual, the other to a pathological state either inherited or acquired.

The term "idiosyncrasy" applies to any peculiarity independent of temperament or diathesis. Idiosyncrasies may arise from inherited or predisposing tendencies, in which case they become a part of the constitution of the individual, and may apparently be latent or undeveloped until some aggravating cause makes them conspicuous. Accident may develop certain traits peculiar to individuals, bringing into prominence unlooked-for features. Diathesis may be aggravated by present disease, but nothing can influence the original organization or modify the vital

activity peculiar to individuals, and which is generally known as temperament.

This subject occupied much of the attention of ancient physiologists, the personal variations in individuals being denominated by some as idiosyncrasies, by others as temperaments. The following, derived from Richerand's investigations on this subject, gives a fair idea of the basis from which the present classification of temperaments is formed: The reasoning of the Greek physiologists was based on the fact that one peculiar system of organs will often be found to modify the whole economy, to impress obvious differences on the general organization, and to hold no less influence over the intellectual than over the physical characteristics. Thus, if the heart, arteries, and veins, which transmit the blood through every part of the body, possess a predominant activity, the pulse will be strong, frequent, and regular; the complexion will be florid; the figure agreeable, although strongly marked; the fleshy parts fine; the fatty matter in the cellular tissue freely deposited; the hair of a flaxen or chestnut color; the nervous susceptibility acute and rapidly impressed by external objects; the ideas quick; the perception prompt; the memory tenacious. Such individuals possess a state of health seldom interrupted by slight diseases, and all maladies, modified by this peculiar temperament, were supposed to have their principal seat in the circulatory system and to produce fever, local inflammations, hemorrhages, etc., which, when in a moderate degree, would often terminate by the power of nature or yield to antiphlogistic remedies. This disposition of the body was denominated the *sanguineous* temperament, and it was conceived that in order that its specific characters should present themselves to the greatest advantage it was requisite that the lymphatic system should harmonize with the energy of the sanguineous, so that both systems of circulation would be in equilibrium.

It was further assumed that if men of this temperament devote themselves to works requiring great exertion of the motive organs, the muscles, moistened with fluids and disposed to a degree of vigor equal to that of the sanguiferous system, increase in size, and the sanguine temperament becomes modified by the peculiarity of the muscular fibres, and a *muscular* or *athletic* temperament is the result, evincing all the external characteristics of force and vigor.

In persons with this combination the head is small; the neck strong, particularly behind; the shoulders broad; the chest large; the hips solid; the muscles strongly defined; the hands, feet, and knees comparatively very small; and the direction of tendons visible under the integument. The susceptibility to mental impressions is not considerable nor the perception acute; but, though difficult to set into action, the individual of athletic or muscular temperament when once aroused from his habitual tranquillity surmounts every obstacle. The Farnesian Hercules presents a model of the physical attributes of this particular constitution of the body. History furnishes only a few instances of men having united with these corporeal powers a degree of intellectual development sufficient to acquire fame not only as warriors but as statesmen. To attain distinction in the fine arts or the sciences it is necessary to

possess an exquisite sensibility, which is lacking in persons of the temperament described.

If the sensibility be both acute and easily excitable, and if in addition there be a capability of dwelling for a long time on the same object; if the pulse be strong, hard, and frequent; the cutaneous veins projecting; the skin brown, inclining to yellow; the hair black; the body moderately fleshy; and the muscles firm and well marked,—if these conditions exist, the passions will be found violent, the mental movements frequently abrupt and impetuous, and the character steady and inflexible—hardy in the conception of a project, constant and indefatigable in its execution. It is among men of this temperament we find those who at different periods have seized the government of various countries; they abound in courage, audacity, and activity; they have signalized themselves by great virtues or great crimes, and have been the terror or admiration of the universe. Such were Alexander, Julius Cæsar, Mohammed, Charlemagne, and in later times Peter the Great, Charles XII. of Sweden, and Napoleon Bonaparte.

This temperament is also characterized by the early development of the mental faculties. The men just enumerated, attaining their manhood, conceived and executed enterprises that would have been worthy of their riper judgment. As full perfection and activity of the liver and obvious superabundance of the biliary juices most frequently coexist with this constitution of the body, in which the vascular system possesses a predominant energy apparently at the expense of the cellular and lymphatic system, the ancients denominated this modification of animal frame the *bilious* temperament. The diseases to which individuals of this class are subject sometimes present a derangement of the liver united with a change in the biliary fluid.

If all the characteristics attributed to the bilious temperament be carried to the highest degree of intensity, and to this condition be added keen susceptibility, the man will be habitually irascible and launch into a passion upon trivial occasions. It is thus Homer has described Achilles and several other of his heroes.

When to the bilious temperament is added a morbid obstruction of some organ in the abdomen or any derangement in the function of the nervous system, and the vital or involuntary organs are weak and irregular in their action, the skin will become deeply tinged, the countenance uneasy and dismal, the pulse hard and habitually contracted. The general physical uneasiness exerts an influence over the mind: the imagination becomes gloomy and the character suspicious. This variation of temperament was denominated by the ancients *melancholic,* and its production was attributed to a diversity of circumstances, such as hereditary disease, long-continued sorrow, incessant study, etc. Thus this temperament was regarded as less a natural and primitive constitution than a morbid affection, either hereditary or acquired.

If the proportion of the fluids be in excess of the solids, this superabundance, which is always in favor of the lymphatic system, gives the whole body an increased bulk consequent on the filling up of the cellular tissues. The fleshy parts are soft; the skin fair; the hair flaxen or sandy; the pulse weak or low; the figure plump; all the vital actions

more or less languid; the memory irretentive; the attention wavering. Those who possess this temperament were denominated *phlegmatic*, and generally have an insurmountable desire for indolence and an utter aversion to exercise, whether of body or mind.

When the property of susceptibility is excessive, impressions received by external organs being quickly recognized, the *nervous* temperament was said to predominate. This temperament was supposed to be rarely natural or primitive, but most frequently acquired, and usually dependent on a sedentary life, reiterated pleasures, exaltation of ideas, maintained by reading works of imagination, as novels or romances. Nervous susceptibility is weak in the phlegmatic temperament, nearly non-existent in the athletic, moderate in the sanguine, and active in the bilious. The nervous temperament is distinguished by a slender make, smallness of muscles—which are at the same time relaxed and wasted by the vivacity of sensations—the promptitude and variability of the determination and of the judgment. Women whose wishes are absolute but changeable, their sensibility very great, frequently present this state of body in all its characters. Sometimes, however, such persons are moderately fleshy, from some degree of the plenitude of the lymphatic tendency being combined with high predominance of the nervous.

By the combination of the various constitutional elements in various proportions the body is *tempered*, that element which is most in excess determining the temper or temperament of the individual. Upon this theory Hippocrates and others have based a classification, claiming as the four primary components of the body the blood, the phlegm, the yellow bile, and the black bile. Whichever of these substances was in excess in an individual produced his peculiar constitution or temperament. Persons in whom blood was excessive were of the sanguine temperament; if the phlegm was superabundant, the phlegmatic temperament; if an excessive quantity of yellow bile was produced, the choleric temperament was the result; and if the black bile was most abundant, the melancholic or atrabilious temperament was developed. The black bile was supposed to come from the spleen, and phlegm to be a watery fluid produced by the brain.

With some variations this is the generally-accepted classification of the present day. Considerable argument may be brought against its acceptance, however, notwithstanding its almost universal adoption. For example, the data of the sanguine temperament are indicative of the healthy conditions of the functions concerned in digestion and blood-making, but these may be destroyed in the course of a few years, or months even. Then, too, we observe in a melancholic temperament something which is perhaps the result of past disease rather than of a peculiarity possessed by the individual whilst in health. Under such circumstances, when sickness will apparently alter the general aspect and appearance so quickly, we are compelled to seek elsewhere for criteria on which to form a classification. The varieties of complexion will to a certain extent furnish some data in persons of the Caucasian race, which has become the dominant race of the globe, but to attempt any definite formulation even with this for a basis would not be entirely satisfactory, as complexions differ markedly in different races, and even

the same race, as already instanced, under the influence of different climatic conditions presents varieties of complexion. Apparently, it is a simple matter to discriminate between the various complexions of individuals of the white races, but take a race of individuals—negroes, for example, highly pigmented and of uniform color: to the ordinary observer they will all appear exactly alike. Each may have individual peculiarities which will with a little experience be recognized, but the uniformity of complexion baffles all trace of that vital tendency which we seek in attempting to determine temperament.

In any classification, then, it is necessary to take into account the general appearance, compare race with race and man with man, in such comparison recognizing certain racial traits common to all, at the same time noting not less obvious differences. One is short and fleshy, another tall and of athletic proportions, a third small and delicate. Another feature to observe is the manner in which the various functions of life are performed: one is full of energy, another moving in a listless, half-hearted manner. Such differences as these, with many others which may be daily observed without detailing them here, are the results and make up the sum of what we know as the temperaments.

One of the more recent classifications of temperaments is that of Dr. Laycock. He endeavors, as he says, to avoid the use of new terms, and to apply the old ones with definite meaning as significant of predominant modes of vital activity. He arranges the temperaments under six heads: first, persons nervously active from predominant innervation; second, those with excessive sanguification and activity of the vascular and muscular systems; third, those combining the first and second divisions, those in whom both innervation and muscular activity are in excess—this he calls the fibrous or bilious temperament; fourth, those in whom the muscular system is developed, but with neither sanguification nor innervation predominant, and a decided tendency to fat deposit exists—this he denominates the phlegmatic temperament; fifth, those lacking or defective in innervation, sanguification, and muscular activity—the lymphatic temperament; sixth, those with defective innervation, sanguification, and vascular activity—the melancholic temperament.

This classification, it will be seen, is based upon the original one of four temperaments, though slightly elaborated. Hutchinson, referring to this classification, says: "As regards its being worth while to distinguish any condition as the nervous temperament because innervation is predominant—or, in other words, the central cerebrospinal system is largely developed—much doubt may reasonably be felt. A high development of the nervous system is a peculiarity of race and of family. The conditions in which the nervous system are subject to disease are rather those of instability than of simple preponderance. The phlegmatic temperament gets its peculiarity from the tendency to fatten; but this tendency is shown in different periods of life, and is much modified by habits of diet and surroundings. So of the lymphatic temperament, in which all functions are sluggish and a general failure of what may be called 'tone' is the conspicuous peculiarity. This condition is not infrequently induced by disease occurring during the lifetime of the individual, and not by any-

thing which can possibly be denoted by peculiarities in the general formation. Dr. Laycock's classification is also, in common with the older ones, open to the criticism that, inasmuch as it takes little or no account of the more conspicuous differences in complexion, it affords us but few facts by which to recognize them. When a man is florid or muscular it is not difficult to say he is of the sanguine temperament; but these conditions are perhaps indicative rather of good digestion and sound health than of intrinsic peculiarities. The appetite may fail and the health give way, and some of the signs supposed to denote temperament may easily vanish. Would it not be more convenient to speak of a man as being simply, for the time being, florid and muscular than by the use of such a term as 'sanguine temperament' to imply permanency in qualities which may easily prove to be otherwise?"

Temperament may, however, be identified by other characteristics than those referred to, each individual presenting them in a more or less marked degree. The same observer says: "There can be no question whatever as to the differences between individuals, nor any doubt as to the importance of the recognition of those differences. By far the commonest error, and one which most interferes with success, is the easy-going habit of regarding all persons as alike, and recognizing differences only in their diseases; or, to put it in other language, of ignoring the predisposing causes and taking account only of immediate ones. In the diagnosis and treatment of disease, in addition to the primary or exciting cause, which is of paramount importance, we have various others which may perhaps be conveniently classed together under the term *contributory*, since they contribute to control and modify final results. Amongst these temperament, the original vital endowment of the individual, is unquestionably a real force, and one which we would most gladly recognize and estimate if we could."

Of the various classifications presented by writers heretofore on the subject of temperaments, we will accept that which is at once the simplest, the most common, and most ancient, and arrange them into the nervous, the sanguine, the bilious, and the lymphatic.

In the person of *nervous* temperament the nervous organization is predominant, and amongst the physical characteristics we find a stature below the medium, slight frame, showing marked predominance of the nervous over the muscular system. In comparison with the body the head is relatively large, the cranium and face being more or less disproportionate. The skin is fine and soft, the complexion light—generally pale and sometimes sallow; the hair fine and dark; and the movements swift and irregular. Any one of these characteristics may be omitted and the person still possess a highly-organized and fine nervous system. A more positive indication of the possession of this temperament is sensibility to internal or external impressions, mental or physical, ready response to sympathy, and promptness in action of both body and mind. A person of nervous organism is often able to endure physical exertion far in excess of that which would be expected from his general appearance, but always at the risk of sudden collapse consequent upon excessive nerve-force expenditure. Such persons are also liable to great fluctuation of feeling, either of exaltation or depression. It has been

remarked that this temperament is confined almost exclusively to or predominates more frequently in highly-civilized countries and in inhabitants of warm climates.

The characteristics of the *sanguine* temperament are rich and strong blood-currents, the whole system as a result of this being well nourished, while the nervous system, whatever its capacity, is in its best condition. Such a person is usually in stature above the medium height, well-proportioned, the chest being specially well developed, and the general movements being graceful, easy, and regular. The head is moderate in size, well formed, the cranium and face being relatively proportionate. The complexion is fresh and ruddy, the hair light or auburn, rarely dark, the eyes light in color, generally blue. As a whole, the organization is vigorous and strong. The mental characteristics are in harmony with the physical, the intellect being vigorous and the imagination brilliant; all mental effort is characterized by ease and promptness; and the disposition is eager and impulsive. Such individuals are impetuous and their judgment has more of promptness than of stability; they are more superficial than would at first appear. The *bon-vivant* has generally a superabundance of the sanguine in his temperament.

The *bilious* temperament is the opposite of the sanguine. The stature of a person of this temperament is medium, and the muscular developments are strongly marked; the body has a firm pose and the movements are energetic, sharp, and expressive, the countenance usually having a severe and serious expression. The complexion is ordinarily sallow, the hair dark, often black, and the eyes black or brown. Mentally, this temperament is characterized by precise judgment, capacity for reasoning, and depth of perception.

The *lymphatic* temperament, as its name implies, is associated with a failure on the part of the lymphatic system to execute the office for which it is designed—that is, the removal of effete or waste substances from the body. These substances retard the real vigor of the man, and, in addition to being valueless, clog the circulation and interfere with the vital movements. The characteristics of this temperament are—fulness of body, frequently amounting to obesity; the features are full, heavy, and expressionless; the outlines of the figure are without grace or beauty; the movements are slow and undecided; and the whole bearing sluggish. Contentment and good-nature are characteristic of this class; also a desire for repose and a dislike for everything requiring active exertion.

It will be obvious from this summary of the attributes of the various temperaments that a comparatively small number of the human race can be definitely classed as being either purely nervous, sanguine, bilious, or lymphatic, but that each possesses the characteristics of two or more; so that it may be inferred that all temperaments are in combination. To the whole economy something is contributed in excess or deficiency by the nerves, the blood, the liver, and the lymphatic system, the characteristics resulting from a predominance of one of these systems of organs forming the basal temperament, the others adding their elements to modify the whole. The most frequent combinations are the nervous and sanguine, the nervous and bilious, the lymphatic and sanguine, the

The Four Basal Temperaments, and their General Indications.

	INDICATIONS.	BILIOUS.	SANGUINEOUS.	NERVOUS.	LYMPHATIC.
1	General Form or Framework.	Tall, angular, massive; square-built.	Full, firmly-rounded contour development; medium height; robust.	Delicate; slight, but erect and well-proportioned.	Bulky; heavy; clumsy.
2	General Movement.	Steady, and persistent.	Full, graceful, and easy.	Rapid but fitful in movements; quick in the sense of frequent.	Unsteady; uncertain; loose-jointed; sluggish; deliberate.
3	Muscular Development.	Knotty; prominent; hard; tense; well-developed.	Well-rounded and graceful.	Well-defined; light, but sinewy.	Large, but flabby and ill defined.
4	Chest or Thorax.	Square and capacious; good expansive power.	Well-rounded and capacious; deep and full.	Not broad, but prominent; very expansive.	Large, but lacking in expansive power.
5	Voice, Quality of.	Strong, but inclined to harshness.	Smooth; sonorous; full.	Not very strong, but clear, penetrating, and ringing.	Poor in vibration, but often soothing and quieting in quality.
6	Complexion and Skin.	Brownish-yellow; tense, and inclined to roughness; dry.	Florid; smooth; warm and dry.	Abounding in grayish tints; fine in texture, and elastic.	Pallid: muddy; moist and cold.
7	Favorable Endowments or Advantageous Indications.	Strength; endurance; fortitude; decision; firmness.	Hopeful; enthusiastic; aspiring.	Remarkable recuperative power.	Gift of self-control; calm; cool; quiet.
8	Unfavorable Endowments or Disadvantageous Indications.	Inclined to melancholy; despondent.	Lack of self-control; impetuous.	Mental fitfulness, and inclined to rapid degeneration or retrogression.	Inertia; low recuperative power in pathological conditions.
9	Cranial Contour.	Square forehead and cranium.	Rounding and full forehead and cranium.	Cranium inclined to preponderate over face.	Forehead low and not shapely: often receding and flat.
10	Facial Contour.	Angular; high cheek-bones.	Round and full.	Delicately oval.	Flat-faced.
11	Hair.	Black and closely curling; inclined to coarse.	Golden to light chestnut; slightly wavy.	Brown; wavy; fine.	Coarse; straight; drab, and sparse.
12	Eyes.	Average size; black, and strong in expression.	Large; full; clear; round; blue.	Above average in size; dark-brown; perceptive in expression.	Small, expressionless, and grayish.
13	Eyebrows.	Heavy; strong, and straightly marked.	Fairly arched; not well-marked.	Well-marked and arched; finely pencilled.	Sparse and indistinct.
14	Nose.	Strong in outline; Roman.	Straight and shapely.	Finely cut and often delicately aquiline in form.	Flat; alæ heavy.
15	Lips.	Large, and brownish purple.	Ruddy and full.	Fine and grayish-pink.	Large, but not shapely, and pale.

The Teeth as Indicated by Temperament.

General Divisions.	Bilious.	Sanguineous.	Nervous.	Lymphatic.
General Color and Quality of Color.	Bronze-yellow, with strength of power of coloring.	Cream-yellow, and inclined to translucency.	Pearl-blue or gray; inclined to transparency.	Pallid and opaque, or muddy in coloring.
General Form.	Large and inclined to angular; rather long in proportion to breadth.	Well-proportioned; abounding in curved or rounded outlines; cusps rounding.	Length predominating over breadth; fine, long cutting edges and cusps.	Large, but not shapely; breadth predominating over length; cusps poorly defined.
Surfaces of the Teeth	Inclined to transverse ridges and abounding in strong lines; neither brilliancy nor transparency of surface, but slight translucency.	Smooth, or nearly so; elevations and depressions rounded; cutting edges and cusps translucent. Fair degree of brilliancy.	Brilliant and transparent depressions and elevations; abounding in long curves.	Surfaces of incisors devoid of depressions or elevations; opaque and dead in finish, even to cutting edges.
Articulation.	Firm and close; well-locked.	Moderately firm; jaw inclined to rotate in mastication.	Very long and penetrating.	Loose and flat.
Gum Margin or Festoon.	Heavy and firm, but inclined to angularity.	Round and full, as regards both breadth and depth.	Delicate, shapely, and fine; oval in curve.	Thick and undefined in shape.
Rugæ.	Heavy and rugged in shape; squarely set.	Numerous and graceful in outline; not heavy, but well rounded.	Close, not numerous; small and long.	Sparse and flat.

The Dual or Binary Temperaments, and their General Indications.

Indications.	Sanguo-bilious.	Nervo-bilious.	Lymphatico-bilious.	Bilio-sanguine.
Size and General Form.	More than average size; tendency toward irregularity, rather than rotundity of form in male and female.	Whether tall or short, of average size; average osseous, muscular, and contour development.	Decidedly more than average size.	More than average size: not particularly height, but breadth of shoulders, fulness of chest; well-rounded muscularity in the male, and rounded development in the female.
Complexion and Skin.	Fairly smooth; but little color; dark and yellowish in its tinting.	Inclined to dark.	Dark-colored; not smooth, and with tendency toward ephelides, chloasma, moles, etc.	Smooth, soft, and creamy tinted: glowing.
Cranial and Facial Contour.	Cheeks broad; forehead square, good size; jaws large, angular and strong; chin square and large.	High cheek bones; forehead large; jaws small; chin small.	Cheeks average; forehead average; jaws average; chin average.	Cheeks round; forehead large; jaws large and well-formed; chin large and round.
Hair.	Black, or nearly so; coarse and curly, but usually not luxuriant in quantity; beard is universal rather than handsomely set; eyebrows decided, but usually more straight than arched.	Dark, and usually decidedly curly; of average quantity and quality; beard sparse and unequally planted; eyebrows decidedly marked, but not decidedly arched.	Very dark and wavy, and inclined to coarse; beard full and wavy; eyebrows marked and heavy.	Very dark, but not black; more than wavy, but not shortly curly; luxuriant in quantity, and fine in quality; beard full and well-planted; eyebrows decided in their marking and arching.
Eyes.	Very dark or black, and strong rather than lustrous in expression.	Very dark brown; average size, but with much perceptive expression.	Dark and usually strong.	Dark, large, lustrous, and expressive.
Mouth and Lips.	Mouth moderately large; lips average in size; inclined to large, and of a brownish red.	Mouth average size; lips thin and shapely.	Mouth large; lips usually firmly set, and brownish in color.	Mouth moderately large; lips full and red.
Nose.	Large and decided in contour.	Usually very shapely, with slight or decided tendency toward aquiline.	Large, with breadth.	Shapely.
Color and Structure of Teeth.	Dark yellow; good quality; usually very strong.	A combination of yellowish and bluish colors; enamel good; dentine soft.	Yellowish in color; enamel of fair structure and polish; dentine fair.	Rich, dark cream-color; excellent in quality.
Size and Form of Teeth.	Large; flat-arched; strong edges; strong, large cusps.	Long and narrow, with long cusps.	Large, thick edges; short, thick cusps; flat-arched.	Average size; round-arched; nicely developed cusps and edges.

The Dual or Binary Temperaments, and their General Indications—Continued.

INDICATIONS.	NERVO-SANGUINE.	LYMPHATICO-SANGUINE.	BILIO-NERVOUS.	SANGUO-NERVOUS.
Size and General Form.	More than average size; well-built; marked depth of chest and breadth of shoulders.	More than average size; fair but not marked physical development.	Less than average size; decidedly less than average osseous, muscular, and contour development.	Less than average size; decidedly less than average osseous, muscular, and contour development.
Complexion and Skin.	Fair and finely florid.	Very smooth and soft; pinkish and even inclined to florid—sometimes freckled.	Dark and inclined to freckle.	Fair and smooth, with fine color tints.
Cranial and Facial Contour.	Cheeks full; forehead good; jaws average, full, and round; chin average and round.	Cheeks round and slightly full; forehead average; jaws large and full.	Cheeks high boned and prominent; lower part of face inclined to thin; chin small and round.	Forehead high, full, and broad in proportion to the rest of the face; cheeks high and prominent; lower face inclined to thin; chin small and round.
Hair.	Sandy to red; full in quantity and fair in quality; beard sandy to red and wavy; eyebrows light and arched.	Light chestnut; decidedly inclined to curl; beard generally well-planted but not heavy; eyebrows dark chestnut and moderately arched.	Of the peculiar range from dark brown (almost black) to dark red (varnished mahogany); beard sometimes heavy, sometimes scanty, ranging in color like the hair; eyebrows either decidedly arched or almost straight, but usually marked.	Light and curly; of fine quality, with decided inclination to baldness; beard scanty, but pleasing both in quality and length; eyebrows light and arched.
Eyes.	Light hazel to clear blue; usually larger than average.	Gray-blue and expressive.	Less than average size; in color from hazel or lighter to dark brown or almost black.	Blue or gray; full; inclined to large, and expressive.
Mouth and Lips.	Mouth average size, but with a fulness of lip which gives it an appearance of more than average; lips full and red.	Mouth medium and oftentimes beautifully shaped; lips dark pink.	Mouth average size; lips may be either thin or full.	Mouth average or small; lips full.
Nose.	Usually shapely and inclined to large.	Usually very shapely.	Generally thin, and either prominent at the bridge or pointed and somewhat upturned.	Thin, prominent, and shapely.
Color and Structure of Teeth.	Rich cream color; enamel and dentine of excellent structure.	Grayish cream; enamel fair; dentine fair.	Generally bluish; enamel fair; dentine soft and sensitive.	Bluish cream color; enamel good; dentine usually sensitive, sometimes exquisitely so.
Size and Form of Teeth.	Average size, handsome shape, rounded arch, good and shapely edges and cusps.	More than average size; shapely edges and cusps; rounded arch.	Variable in size and form; in one patient broad, and in another long, with narrow necks and long cusps.	Average size; shapely; inclined to length, and with narrowish necks.

The Dual or Binary Temperaments, and their General Indications—Concluded.

Indications.	Lymphatico-nervous.	Bilio-lymphatic.	Sanguo-lymphatic.	Nervo-lymphatic.
Size and General Form.	Average size; less than average osseous and muscular, but more than average contour development.	Decidedly more than average size, but with largeness of development neither beauty of form nor strength of structure.	More than average size; full, round development.	Average size; average development.
Complexion and Skin.	Dark or light, but generally devoid of freshness and color.	Dark, pallid, and opaque.	Soft and smooth; color ranging from ivory whiteness to light pink, and handsomely tinted.	Light; pallid; deficient in quality.
Cranial and Facial Contour.	Cheeks inclined to full; prominent; rounded; forehead broad and high; jaws average; chin small, well formed.	Cheeks large, but not prominent; forehead large, but inexpressive; jaws large and rounded; chin large and round.	Cheeks large and full; forehead broad and moderately high; jaws full and round; chin large and round.	Cheeks full and somewhat prominent; forehead good, and usually high; jaws average; chin average; round.
Hair.	Medium in color, but straight, or at most slightly wavy; beard sometimes a most wanting; eyebrows not marked or arched.	Dark, moist, and straight; generally in good quantity, but lacking in quality; beard moderately heavy, dark, and straight; eyebrows marked.	Dark to light chestnut: straight or wavy: of average quantity; sometimes luxuriant, and of good quality; beard not heavy; brown and soft; eyebrows light or dark, but not decidedly arched.	Straight and medium in color; beard straight and medium in quantity and quality; eyebrows marked and arched.
Eyes.	From dark gray to light gray (modifications of this temperament sometimes produce apparent anomalies, as dark hair with very light eyes, or light flaxen hair with black eyes).	Dark gray to quite dark; moderately large, but wanting in expression and power.	Light, large, and mildly hopeful in expression.	Medium size; grayish, inclining either to green or hazel.
Mouth and Lips.	Mouth average or small; lips fairly full.	Mouth large; lips full and bluish or brownish-pink in color.	Mouth large; lips full.	Mouth average; lips usually shapely.
Nose.	Average; somewhat decided in contour.	Large, full, and broad.	Shapely.	Average; not decided in contour.
Color and Structure of Teeth.	Grayish-blue; soft, and frequently quite sensitive.	Yellowish in color; of good polish, but of suspicious opacity.	Creamy-gray; enamel fair, not strong; dentine fair.	Bluish-gray; soft, and somewhat sensitive.
Size and Form of Teeth.	Average, or less than average size; shapely, with rounded arch.	Usually large; thick edges; short, thick cusps; flat-arched.	More than average size; broad, round-arched.	Average size; good shape; neither long nor short; with rounded arch.

lymphatic and bilious, bilious and sanguine, sanguine and bilious, and the nervous and lymphatic. Twofold or binary combinations are the simplest forms, but many individuals have the peculiarities pertaining to three of the temperaments, and thus we have threefold or ternary combinations, as sanguo-lymphatico-nervous or nervo-bilio-lymphatic. Not infrequently the whole four temperaments are found incorporated in one individual, though rarely in equal proportions. The ancient physiologists, assuming the possibility of an equal distribution of temperamental attributes, spoke of the *temperamentum temperatum*, referring to the temperate, harmonious, or balanced temperament in which the characteristics would be in equipoise.

The dento-temperamental classification is dual or binary. Commencing with the bilio-sanguine, the best results being obtained with teeth belonging to this temperament, the scale gradually descends until the nervo-lymphatic is reached.

The basal temperaments are the bilious, sanguine, nervous, and lymphatic. The preceding tables (pp. 1038 and 1039), prepared by Dr. E. M. Flagg, give the general indications and the dental characteristics of each.

In the table of Dual or Binary Temperaments (pp. 1040–1042), prepared by Professor J. Foster Flagg, will be found the general indications pertaining to the sanguo-bilious, nervo-bilious, lymphatico-bilious, bilio-sanguine, nervo-sanguine, lymphatico-sanguine, bilio-nervous, sanguo-nervous, lymphatico-nervous, bilio-lymphatic, sanguo-lymphatic, and nervo-lymphatic temperaments.

The shape of the alveolar arch and the dome or roof of the mouth, also the articulation of the teeth and the manner in which the gum is festooned over each tooth, are all indicative of the several temperaments and present varieties worth attention.

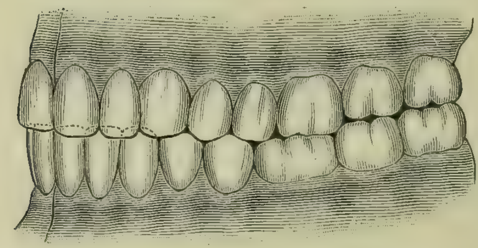
The arch of the Bilious temperament (Fig. 943) from cuspid to cuspid is almost flat, the lines backward from these points slightly diverging

Fig. 943.

Fig. 944.

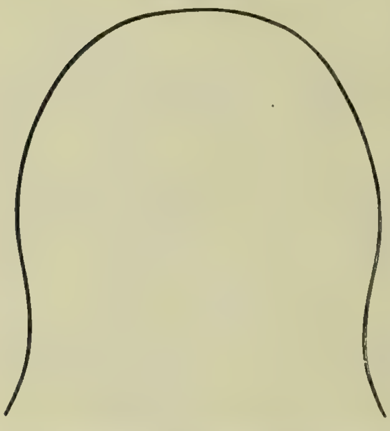
in an almost straight line. The dome (Fig. 944) of the mouth is high and almost square. When articulated the upper central incisors overlap the lower, and are closely locked, as represented in Fig. 945. In general form the teeth are large, the corners tending to squareness, and are

FIG. 945.



rather long in proportion to their breadth; in texture they are dense and strong. The proximal surfaces are in close contact two-thirds of the distance from the cutting edge to the neck, rendering the festoon of the gum short and heavy.

FIG. 946.

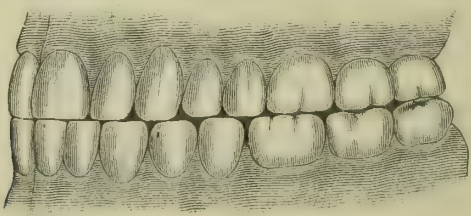


The Sanguine arch (Fig. 946) resembles a horseshoe in shape. The dome of the mouth is high and semicircular (Fig. 947). The articulation of the teeth is close and firm, and their structure is dense. The masticating surfaces of teeth in this class frequently bite edge to edge, and as age advances they are gradually worn down to the gum unless protected by artificial means. In general form (Fig. 948) they are well proportioned, length predominating in less degree over breadth, and their out-

FIG. 947.

lines are rounded and curved. The distal and mesial surfaces are in

FIG. 948.



contact a little more than half the distance from the cutting edge, and the festoon is long and delicate in outline.

The arch of the Nervous temperament (Fig. 949) presents a strong

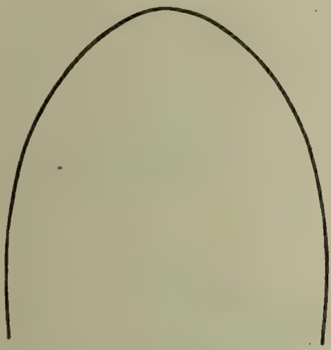


Fig. 949.

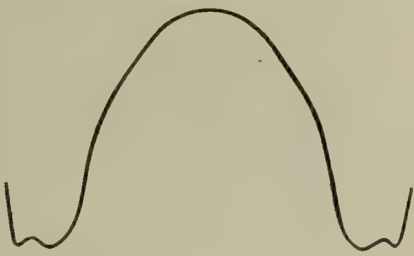


Fig. 950.

contrast to either of the two preceding, and is sometimes spoken of as Gothic, from its pointed character. From the central incisors, which

Fig. 951.

often overlap for want of space, the line of the remaining teeth continues backward with a slight curve, the greatest prominence being between the cuspid and first bicuspid. The roof of the mouth partakes of the same curve and angle as the arch (Fig. 950). The articulation of the teeth (Fig. 951) is not close, but long, and the teeth belonging to this temperament are of average density and structure. In shape, length predominates over breadth; the distal corner of the centrals is rounded, giving the whole tooth almost the appearance of a lateral; and the cusps and cutting edges are long and fine. The point of contact of the proximal surfaces is near the cutting edge, giving a long, delicate festoon to the gum.

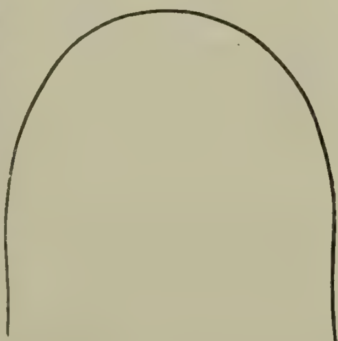
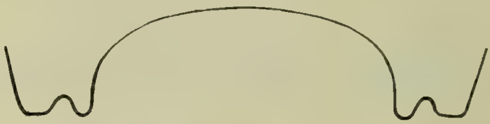


Fig. 952.

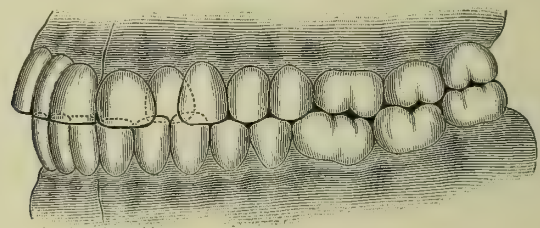
The Lymphatic arch (Fig. 952) is almost semicircular in its outline, and somewhat resembles that of the sanguine temperament. The dome or roof of the mouth is flat and low (Fig. 953). The articulation is

FIG. 953.



irregular (Fig. 954), and the front teeth are apt to protrude. In shape, breadth predominates over length, and the normal depressions and elevations are either entirely absent or undefined. The festoon of the gum

FIG. 954.



is thick and indefinite in outline. The lateral on either or both sides is frequently out of line, as represented in the figure.

To obtain good results in the practice of operative dentistry a knowledge of the attributes pertaining to the various temperaments may be desirable, but in the practice of prosthetic dentistry, where the natural organs are to be replaced by an artificial denture, such knowledge is absolutely necessary.

"A certain law of harmony in nature between the teeth and other physical characteristics necessitates respect to size, shape, color, and other qualities in an artificial denture in order that it shall correspond with other indications of temperament; and if teeth correlated in their characteristics to those which nature assigns to one temperament be inserted in the mouth of one whose physical organization demands a different type, the effect is abhorrent. The artificiality of artificial teeth is the subject of remark by those who have little or no conception of the reason therefor—simply an instinctive appreciation of the incongruity and unreality. It is indeed rare to see a case in which there is occasion for a moment's hesitation as to the fact of replacement. There is no dental service that from the æsthetic standpoint is, as a rule, so illy performed as the prosthetic. Thousands of dentures are constructed which serve the needs of the wearer for speech and mastication, but which are nevertheless deserving of utter condemnation as art-productions. More attention has been paid to the best methods of restoring impaired function—securing comfort and usefulness in artificial dentures—than to a correlation of the substitutes to the physical characteristics of the patient.

"What is needed is such an appreciation of the law of correspondence

that the dentist can cipher out, as by the rule of three, the character of teeth required in the case of an edentulous mouth with the same precision as the comparative anatomist can from a single bone indicate the anatomical structure of the animal to which it belonged.

"The probability is that in many, perhaps in most, of the cases of artificial dentures the fault is not in carelessness or indifference of the dentist, but in failure to recognize the requirements of temperament. A certain family resemblance to each other in a set of teeth is considered essential, but the adaptability of the set as a whole to a given case should be esteemed of even greater importance. Especially is there a notable failure to recognize the color demanded by form. A set of teeth in which not only the relative length and breadth, but every line and curve, characterizes it as belonging to a certain temperament, is, in contravention of every law of correspondence, made of a color which was never found in nature associated with such forms. Thus we see constantly such incongruities as the association of the massive tooth of the bilious temperament with the pearl-blue color belonging to the nervous temperament, and the long narrow teeth of the nervous temperament, of the bronze-yellow color, never seen in any but those of a bilious temperament. The trouble is not with the manufacturers: they supply the demand. The fact is the requirements of the laws of correspondence have not been sufficiently studied by the profession.

"The first study of the dentist who aspires to the dignity of an artist, when proposing to replace a lost denture, should be how to restore the natural appearance of his patient; and this can only be effected through the appreciation and observance of the temperamental characteristics and the law of correspondence or harmony. Age and sex may somewhat modify the requirements in a given case, but the basal fact on which he should proceed is temperament. A failure to recognize its demands will result in failure from an æsthetic standpoint. A knowledge of the distinguishing characteristics of the various temperaments and the style of teeth which conforms to nature's type in the physical organization marks the difference between the dental mechanic and dental artist."[1]

All works which required skill were formerly termed "works of art:" this expression may now be qualified, and the distinction drawn between the ideal arts, or those which appeal to our higher emotions, and the mechanic arts, or those which contribute more directly to physical requirements and are active in promoting health and comfort. All that relates to the appearance of an artificial denture belongs to art, but all that affects its utility belongs to mechanics.

To satisfactorily make an artificial denture, in addition to its utility in supplying the place of the natural organs in the process of digestion it must preserve the contour of the face and lips formerly supplied by the teeth and alveolar processes; it must also be in harmony with the general appearance, physiognomy, and temperament of the wearer; and it is in this connection that the art-relations of dentistry may be considered. In order to fully comprehend these relations it is necessary to study the general form of the face both in profile and full view, as to remedy a de-

[1] Edit. *Dental Cosmos*, Feb., 1884.

formity the requirements must first be known, and to artistically embrace these in any piece of work it is necessary to have a standard or ideal. To have the various features mathematically proportionate would be to have them appear unnatural, but there are certain rules for obtaining the measurements required in drawing the head in profile which show the relative proportions assigned to different parts of the face. Wiegall, in his *Art of Figure-Drawing*, says: "First draw a vertical line equal in length to the height of the intended head, and then draw two straight lines at right angles to it at its extremities; these two horizontal lines will touch the top of the head and lowest point of the chin respectively. Divide the four vertical lines into four equal portions (Figs. 955 and 956).

Fig. 955.

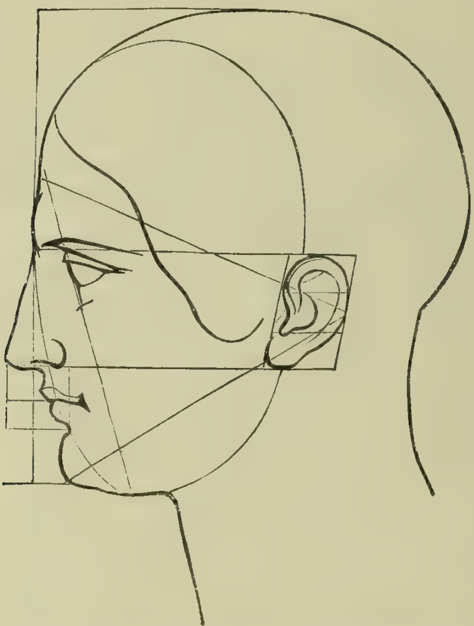
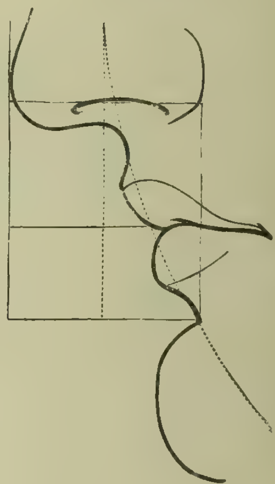


Fig. 956.



"The first portion marks the vertical distance between the top of the head and the front roots of the hair; the second, that from the hair to the root of the nose (between the eyes); the third, the length from thence to the bottom of the nose; the fourth, that from the bottom of the nose to the bottom of the chin.

"Bisect this fourth portion, and the point of bisection determines the lower point of the under lip.

"Again divide this last part (*i. e.* from the nose to the front of the under lip) into three portions: the lowest portion determines the thickness of the under lip; the next above determines the thickness of the upper lip; the uppermost, which is rather longer than the middle one, determines the distance between the nose and the upper lip.

"These points being determined on the vertical line, next draw

between the horizontal lines, but touching only the lower one, an oval, the larger diameter of which, being vertical, is to be equal to the length of the vertical line from its top to the point marking the opening of the mouth or the top of the upper lip, and its lesser diameter equal to three-fourths of the larger, and let it be placed so that the extremity of its lesser diameter may touch the vertical line a little above the point marked for the roots of the nose. If this oval be carefully drawn, in its course it will pass somewhat behind the front opening of the mouth and the middle of the upper lip, and through the commencement of the chin under the lip; it will determine the angle of the under jaw (not its course); and it will pass through the centre of the ear. From the point on the vertical line opposite the upper lip draw a straight line perpendicular to the vertical and meeting the oval; the bisection of this straight line will give the commencement of the upper lip. The projection of the nose before the vertical is nearly equal to the distance from the bottom of the nose (where it intersects the vertical) to the opening of the mouth. The vertical line dividing the nose equally, the width of the wing of the nose is equal to its projection in front of the nostril.

"If a straight line parallel to the vertical be drawn somewhat behind the wing of the nose, and intersecting the oval below the under lip, the point of intersection is the commencement of the chin.

"The length of the mouth is equal and parallel to the projection of the nose before the face.

"The length of the ear is equal to that of the nose, and its place is found by its centre being in the oval (distant at the length of two noses from the facial line), therefore by its being parallel with the nose and equidistant from the top of the head.

"The highest part of the head lies immediately over the top of the ear.

"A line drawn from the middle of the forehead to the middle of the chin will give the inclination of the eye, the position of which is further determined by the top of the eyelid being opposite the root of the nose.

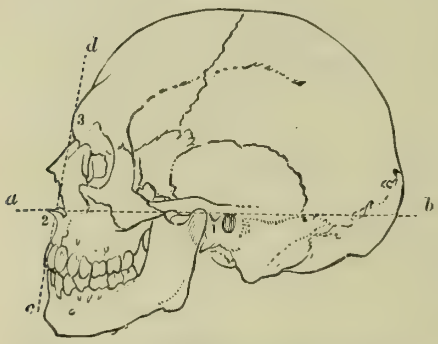
"And if upon the straight line drawn from the middle of the back of the ear to the middle of the forehead an equilateral triangle be drawn, its vertex determines the point of the chin."

In accepting a figure in accordance with these rules it should be remembered that "Nature never repeats herself, even in two sides of a leaf. Such precision belongs to machine-work; and in studying Nature we learn that variety is no less necessary to a pleasing composition than unity. To the grace and beauty of the whole work harmony is indispensable. Without harmony each part may fail of the effect intended, however true in design. There must be harmony of grouping, harmony of light and shade, harmony of coloring, harmony of expression; each part must be adapted to correspond to the rest. The attitude must be in keeping with the expression, the color with the subject treated; and the accessories must be true both to the character and age represented: harmonious whole is always more or less pleasing in itself, independent of subject or style."

The face, as a whole, presents a special interest when we compare its

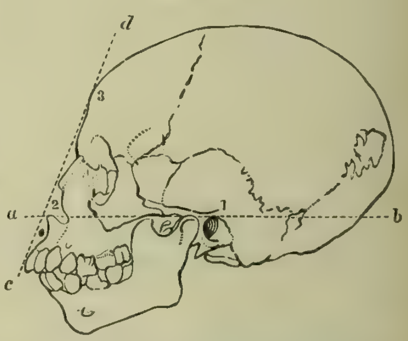
development with that of the skull in various individuals and races. The more prominent the skeleton of the face, the less the skull (forehead) is developed. Camper describes his method of measuring the relative development of the skull and face thus: "The basis on which a distinction of nations is founded may be displayed by two straight

Fig. 957.



Facial Angle of the Skull of the Caucasian Race: *a b* and *c d*, the lines which mark this angle; 1, the external auditory meatus; 2, base of the nose; 3, the most prominent part of the forehead.

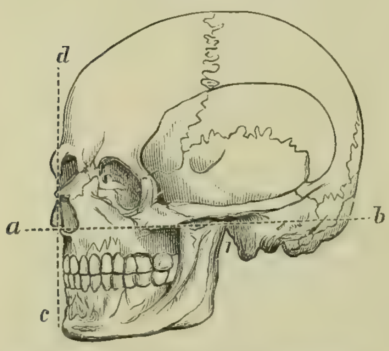
Fig. 958.



Facial Angle of a Negro. The figures are the same as in the preceding illustration.

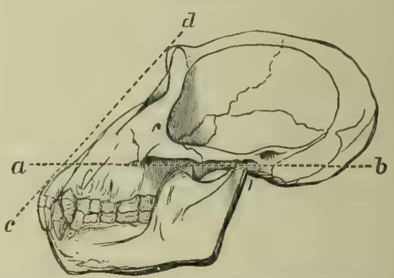
lines, one of which is to be drawn through the meatus auditorius to the base of the nose, and the other touching the prominent centre of the forehead, and falling thence on the most advancing part of the upper jawbone, the head being viewed in profile. In the angle produced by these two lines may be said to consist not only the distinctions

Fig. 959.



Facial Angle of the Skull of a Frenchman: *a b* and *c d*, the lines which mark this angle.

Fig. 960.



Facial Angle of the Skull of a Chimpanzee: *a b* and *c d*, the lines which mark this angle.

between the skulls of the several species of animals, but also those which are found to exist between different nations." The oblique line, it will be noticed, is on a level with the incisor teeth and the most prominent part of the forehead.

In the series of skulls represented in Figs. 957, 958, 959, and 960

it will be seen that the nearest approach to a right angle is in the best-developed or most-civilized races, the facial angle decreasing in proportion as the scale of development is descended from the white to the yellow and black races and the lower animals. The same observer says: "The angle which the facial line, or characteristic line of the visage, makes varies from seventy to eighty degrees in the human species. All who raise it higher disobey the rules of art (from imitation of the antique); all who bring it lower fall into the likeness of the monkeys. If I cause the facial line to fall in front, I have the antique head; if I incline it backward, I have the head of a negro; if I incline it still farther, I have the head of a monkey; inclined still more, I have that of a dog, and lastly that of a goose."

In applying this reference to the facial angle to our subject, attention is drawn to the localities more directly concerned—the nose, mouth, and chin—and comparison must be made of the configuration of these parts as seen in the skulls represented, the variation in outline being so distinct as to mark the difference between beauty and ugliness. The Grecian (Caucasian) head is generally accepted as the highest type of physical and intellectual beauty (Fig. 961), complying in all respects with the requirements of art and in accord with the angle referred to in not exceeding 80°. The line from the top of the forehead to the end of the nose is almost straight; the curve of the nostrils is symmetrical with that of the mouth; the upper lip is prominent, short, and finely curved, the lower lip being full, round, and not quite so prominent, and marked at its base by a depression known as the mento-labial groove. The upper lip receives its general conformation from the alveolar processes and teeth, and its curve is continuous with that of the cheeks. It is slightly in advance of the lower lip, as the alveolar process of the upper jaw is in advance of that of the lower jaw. When this support is wanting, as is the case in edentulous mouths, the processes having been absorbed, the lips lose their fulness and contour; the naso-labial groove becomes deeper and longer; the wings and end of the nose are drawn down; the cheeks, instead of presenting their natural convexity, become slightly concave; and the commissure or angle of the mouth is depressed and drawn down.

FIG. 961.

In remodelling a face and restoring its lost curves and contours to their original position much judgment is required, observation of the face in profile being of the first importance, the rules given on p. 1048 presenting the type or pattern, which should be followed as closely as possible to conform with the general appearance. In addition to this, the aspect of the features, also the age and temperament of the individual, are to be considered, and with them the color, shape, and length of the teeth should harmonize. When supplying a full upper and lower denture, to prevent elongating the face or drawing up the lower jaw

and giving the aged appearance so frequently noticed, the distance from the root of the nose to the top of the upper lip should be obtained, and should be the same as that from the point of the chin to the top of the upper lip. In this way a correct articulation is secured, and much of the lost natural expression of the lips is regained.

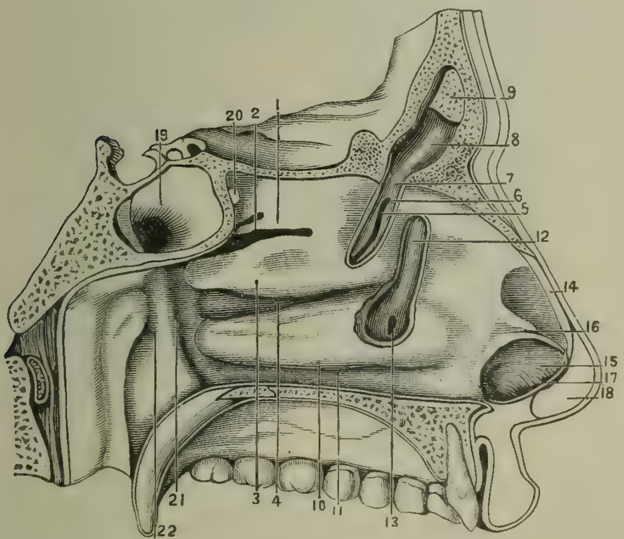
To obtain the best results no definite rules can be laid down, as each case varies as do individuals, the art of restoring expression being acquired only by observation and experience. An error is frequently made by attempting to follow a rule too closely in the endeavor to secure perfection of form; but it is quite evident that there can be no general rule which will apply to the innumerable varieties, individual or national, that are constantly met. All these are deviations from the recognized standard, and a knowledge of that first obtained gives ability the more readily to detect them and see wherein the difference lies.

OBTURATORS AND ARTIFICIAL VELA.

By HENRY A. BAKER, D. D. S.[1]

The hard palate is a bony plate, covered by mucous membrane, forming the floor of the nose and the roof of the mouth. The palatal processes of the superior maxillæ when in apposition form its anterior three-fourths, the remaining part being made up by the horizontal plates of the palate bones (Fig. 965). The soft palate, Fig. 966 (velum pen-

Fig. 965.



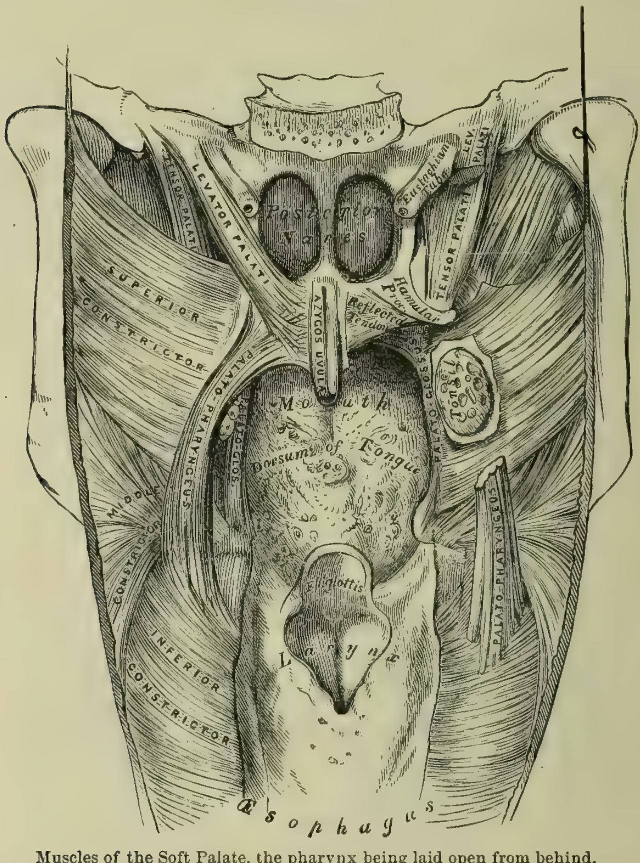
1, superior turbinated process; 2, superior meatus; 3, inferior turbinated process; 4, middle meatus; 5, portion of the turbinated processes of the ethmoid bone, removed to exhibit the orifice of communication (6) with the anterior ethmoidal sinuses; 7, communication with the frontal sinus; 8, left frontal sinus; 9, part of the unsymmetrical partition separating the frontal sinuses; 10, turbinated bone; 11, inferior meatus; 12, lachrymo-nasal duct, exposed by removing a portion of the bones; 13, its termination; 14, edge of the upper lateral cartilage; 15, outer part of the left nostril; 17, cut edge of the cartilage of the partition; 18, inner portion of the left lower lateral cartilage; 19, sphenoidal sinus; 20, its orifice; 21, pharynx; 22, orifice of the Eustachian tube.

dulum palati), is a movable septum or curtain attached to the posterior border of the palatine arch and continuous with the hard palate. It is a membranous body controlled by five pairs of muscles—two superior, one intermediate, and two inferior. These, in conjunction with the mus-

[1] The writer is much indebted to Dr. Robert S. Ivy of Philadelphia for valuable assistance rendered in the collection and arrangement of material for this paper.

cles of the pharynx, tongue, and hyoid bone, assist in the action of deglutition, propelling the food into the œsophagus without any portion being permitted to enter the nasal cavity or larynx, though persons with cleft palate are seldom inconvenienced by such an occurrence: as the act of

Fig. 966.



Muscles of the Soft Palate, the pharynx being laid open from behind.

swallowing is so frequent, by constant use they involuntarily educate other muscles to perform the office of those which are deficient. During the act of speech also the soft palate is either raised or depressed to assist in forming cavities of resonance of greater or less capacity.[1] It is for the treatment of any defect in the afore-mentioned parts, whether natural or accidental, that artificial vela and obturators are employed.

Congenital cleft palate is the result of a lack of development of the maxillary bones, arising from various causes, among others being hereditary disease, malformation during embryonal life, or lack of nourishment of the bones involved, the trophic nerve-supply being impaired.[2]

[1] For fuller treatment of this subject see the article on the "Physiology of Voice and Speech," Vol. III.

[2] See "Development of Superior Maxillary Bone," Vol. I. p. 80.

There are marked varieties in the form, general appearance, and size of cleft palates, and they are naturally divided into those which are congenital and those which are the result of disease. Congenital cleft of the palate may extend entirely through both the hard and soft palates, and may be complicated with complete fissure of the alveolar process and with hare-lip, as in Fig. 1009. Usually, however, the cleft is less extensive, being confined to the palate bones and the soft palate.

Congenital cleft of the palate was at one time as commonly treated surgically as by mechanism. The former treatment has, however, been nearly or quite abandoned in recent years for two very good reasons: First, it is a very painful one for the patient and difficult for the operator, and failures of closure are largely in the majority; second, it universally fails to improve the speech even after a successful closure.

Notwithstanding the above facts, many physicians still recommend staphylorraphy. They must certainly do so from want of knowledge of the anatomy and physiology of the vocal organs and their use in the mechanism of speech, which is the production of sound, and its direction through the nasal passage or the mouth at will, the vocal sound being controlled by certain organs whose modification and resonance give the ability to form articulate speech.

One of the most important aids in producing the above results is the soft palate. This organ is lifted up and comes in close contact with the posterior pharyngeal wall, thus shutting off the nasal passage, this being absolutely essential in producing all excepting nasal sounds. After the operation of staphylorraphy such a closure is impossible, owing to the soft palate having been made too short and tense; hence speech still remains defective.

Accidental Cleft Palate.—Lesions of the palate not congenital may be caused either by accident or disease. These cases may be successfully treated by very simple appliances, while the same amount of skill exercised on a congenital cleft would have no beneficial result. This may be accounted for by the fact that in the former case the patient before the accident had learned to articulate distinctly and use the organs of speech efficiently and correctly, while persons who are thus deformed from birth are obliged to learn the art and methods of articulation by slow and painful processes, the organs requiring the training which is necessary for one who acquires a new language. Hence the appliance for relief should not only fill up the gap in the defective palate, but should also be so constructed as to work on physiological principles in harmony with the natural movements; that is to say, it should be under perfect control of the surrounding muscles. It is manifest, therefore, that the success even of the most scientifically adjusted instrument depends largely upon the co-operation of the patient who uses it.

The appliances for the relief of the above malformations, whether congenital or accidental, are described as obturators and artificial vela.

Dr. Norman Kingsley, in adopting this classification, says: "All apparatus adapted to the roof of the mouth, whether forward or back, to the hard palate or soft palate, may properly be designated as *artificial*

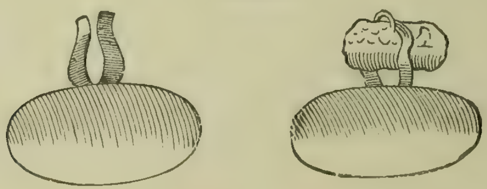
palates; but as such instruments may be divided into two distinct classes, operated on different principles and applied in the main to entirely different cases, without the possibility of interchange of principle, I therefore denominate the one an *obturator* and the other an *artificial velum.* An obturator, according to this distinction, is a stopper, plug, or cover, hard, non-elastic, and stationary, fitting to an opening with a well-defined border or outline, and shutting off the passage. Such instruments are of nearly universal application to perforations of the hard or soft palate resulting from accident or disease, but they are rarely applicable to a congenital fissure of the velum. An artificial velum is not a stationary stopper, but an elastic, movable valve under the control of the surrounding and adjacent muscles, closing or opening the passages at will, and is applicable especially to congenital fissures, occasionally where the soft palate has been destroyed, but never to perforations of either the hard or soft palate."

Obturators.

Among the more primitive forms of obturators may be mentioned those of Paré, who in 1541 recorded his efforts to supply defects in the hard palate as follows: "Manie times it happeneth that a portion or part of the bone of the Palat beeing broken with the shot of a gun, or corroded by the virulencie of the *Lues Venerea*, falls away, which makes the patients to whom that happeneth, that they cannot pronounce their words distinctly, but obscurely and snuffling; therefore I have thought it a thing worthie the labor to shew the means how it may bee helped by art. It must be don by filling the cavitie of the Palat with a plate of gold or silver, a little bigger than the cavitie itself is. But it must bee as thick as a French Crown, and made like unto a dish in figure; and on the upper side, which shall bee towards the brain, a little sponge must be fastened, which, when it is moistened with the moisture distilling from the brain, will become more swollen and puffed up; so that it will fill the concavitie of the Palat, that the artificial Palat cannot fall down, but stand fast and firm as if it stood of itself. This is the true figure of those instruments, whose certain use I have observed not once or twice, but by manifold trials in the battels fought beyond the Alps.

"The figure of plates to supplie defects of the Palat (Fig. 967):

Fig. 967.



"The figure of another plate for the Palat, on whose upper side there is a button, which may be turned when it is put into the place, with a

small Raven's bill (forceps)."[1] This last-mentioned figure is represented in Fig. 968. It was made in two parts, the one screwing into the other, and was sustained in position by revolving the smaller portion until it bridged the orifice.

FIG. 968.

Such appliances fulfilled all requirements so far as closing the perforation is considered, but after being used a short time they lost their efficiency through the absorption of the surrounding tissues caused by constant pressure, and a gradual enlargement of the aperture was the result.

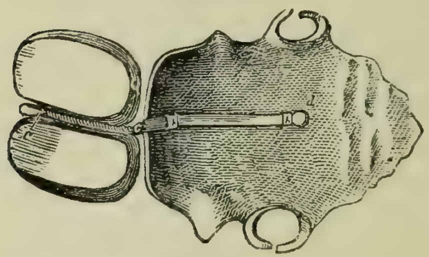
Various forms of appliance were attempted with more or less success in individual cases. Among them may be mentioned one reported in the *American Journal of Dental Science* by Dr. S. P. Hullihen for a case where the velum was lost by disease. In describing it he says: "An artificial palate made upon this plan will be composed of four parts: 1, a valve, made from gold plate, as thin as it can well be worked; 2, a spiral spring about an inch long, and of the size usually made for whole sets of teeth; 3, a slide, one inch and a half in length, and of the width and thickness of a common watch-spring; 4, a plate, larger or smaller, as the case may require, struck up in the usual way, to fit the roof of the mouth. The size and form of the valve are obtained by taking an impression of the posterior opening of the nares. The plate composing it should be struck up in two parts, front and back, which, when soldered together, makes a hollow body (a), as shown in Fig. 969. At the upper end of the valve a small pin is soldered, the point of which looks downward, and of sufficient thickness to fit very tightly in one end of the spiral spring. The spiral spring must be made of such a length as will permit the valve to rest slightly upon the upper surface of the remnants of the lost velum. The slide has a pin in the posterior end, looking upward to receive the other end of the spiral spring before described. The anterior end of the slide has a small button looking downward. The slide is attached to the plate by two small staples (b b), as represented in Fig. 970. The plate may be made to

FIG. 969.

[1] From the *Workes of that Famous Chirurgion Ambrose Paré*, translated out of Latin and compared with the French, by Thr: Johnson, London, 1649.

cover the entire roof of the mouth when necessary, or it may be made only sufficiently large to permit the mounting of the slide. These different plates, when put together, particularly if the plate is to cover the whole roof of the mouth, make a plate of the form represented by Fig. 969. Fig. 970 shows the attachment of the spiral spring to the valve and slide (*c c*). The staples (*b b*) confine the slide to the plate, and there is a button (*d*) on the end of the slide, by which the valve may be set back or forward, as desired by the patient, without removing the plate from the mouth.

Fig. 970.



"The plate should be made to fit the several parts for which it is intended with great exactness. The plate must fit the roof of the mouth and the teeth to which it may be secured in a faultless manner. The slide must be arranged so as to permit the valve to be drawn so closely against the posterior opening of the nares as to close them or to be pushed back, so as to leave them entirely unobstructed. The spiral spring, as I have before remarked, must be made of such a length as will allow the valve to rest slightly upon the upper surface of the remnants of the lost velum. The valve should be sufficiently wide at its base to overlap the remnants of the velum so far as the parts on each side will permit without producing irritation. No other part of the valve than the base should be allowed to touch, unless when brought forward against the nares. Unless all the parts are so arranged the palate will not be properly constructed, and will not, of course, answer the desired end.

"Thus it will be perceived that the peculiarities of this plate are: 1, a valve to fit the posterior opening of the nares; 2, the attachment of this valve to a slide, by which the patient is enabled to adjust the valve while in the mouth in such a way as to admit through the nares just the quantity of air desired; 3, the mounting of the valve on a spiral spring, which will permit it to vibrate backward and forward as the breath is inhaled or exhaled, and also to be moved by any muscular action that may remain in the remnants of the lost velum, thereby answering, to a great extent, the purposes of a velum."

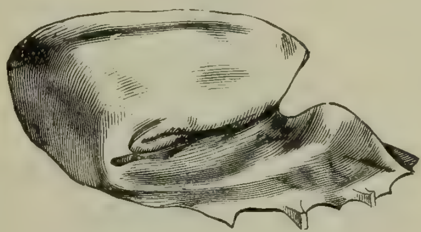
In 1858 a case supplied with an appliance by Prof. Buckingham of Philadelphia is described as follows: "The patient on a previous occasion had had a tumor removed, which covered a portion of the posterior surface of the hard and the anterior surface of the soft palate. The surgeon, on its removal, had divided the velum and uvula, so that the case resembled a congenital deformity. The attempt had been made twice to bring the soft parts together again by a surgical operation, which had failed. Fig. 971 shows the appearance of the parts very clearly—the letters A and B showing the thickened muscles as they hung down on the side of the pharynx. He made for this case an obturator (Fig.

972), the plate of which covered the whole of the roof of the mouth, with a bulb attached to extend up into the posterior nares, and well

FIG. 971.

back toward the antero-posterior walls of the pharynx, leaving but a small space between them. This obturator enabled the patient to eat and drink without annoyance; without it food would pass into the nares and occasion much inconvenience. It also greatly assisted his voice, as many of his words could not be understood when it was not worn, but he could articulate them with great distinctness when it was in place."

FIG. 972.

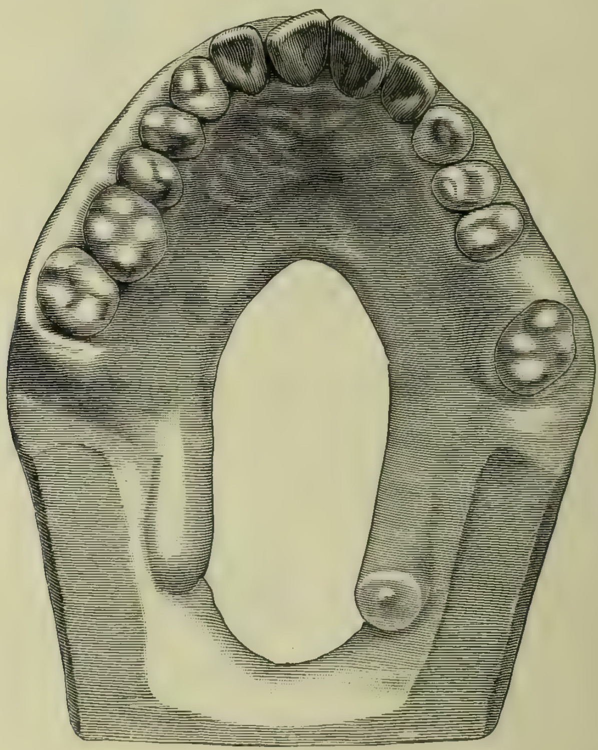


In 1883 this case came under the care of the writer: the opening was then much larger; its appearance is represented in Fig. 973, obtained from an impression taken at that time. The posterior part of the opening showed the unmistakable advance of the superior constrictor muscle. An appliance was made for the case on the principle described and represented in Fig. 991. The result was much more satisfactory to the patient, as it enabled him to speak more distinctly; and after wearing the appliance a short time he was entirely relieved of the catarrh with which he had been troubled. The improvement was due to the more thorough closure of the aperture and the adaptation of the velum to the movements of the muscles with which it came in contact.

Suersen's Obturator.—In 1867, Dr. Wilhelm Suersen introduced an obturator the principle of which has seemed to many the best for obtaining correct articulation, and which has since been frequently used.

Describing it,[1] he says: "In order to be able to pronounce all letters distinctly, it is accordingly necessary (besides other conditions, which are far away from our present subject) to separate the cavity of the mouth from the cavity of the nose by means of muscular motion. That separation is, under normal conditions, effected, on the one hand, by the velum palati, which strains itself (consequently by the levator and tensor palati); but on the other hand, also, by a muscle which, to my knowledge, has, in connection with these operations, not yet received a sufficient amount of attention—I mean the constrictor pharyngeus superior.

Fig. 973.



This muscle contracts itself during the utterance of every letter pronounced without a nasal sound, just as the levator palati does. The constrictor muscle contracts the cavum pharyngo-palatinum, the pharynx wall bulging out; and it is chiefly on the action of this muscle that I base the system of my artificial palates.

"These palates, which in all their parts are made of hard caoutchouc, consist of a teeth-plate suitably attached to existing teeth, and which, at the same time, covers the fissure in the hard palate (if such a fissure exists). Where the fissure commences in the velum, that plate terminates in an apophysis broad enough for filling up the defect. This apophysis is at the same time of such thickness as to keep up a contact

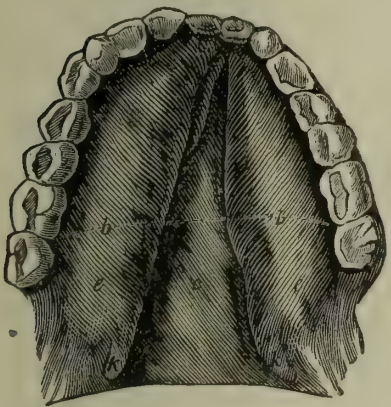
[1] *The American Journal of Dental Science*, December, 1867.

between the high edges forming the sides of the apophysis and the two halves of the velum, even when the levator palati is in activity. To bring about this contact the more surely, the high edges forming the sides do not rise straight, but obliquely, toward the outside. The lower surface of the apophysis, turned toward the mouth, lies on about an equal level with the velum, *if the latter is raised by the levator palati.* But when the velum hangs loosely downward the back part of the artificial palate is lying over it. This back part, accordingly, fills up the cavum pharyngo-palatinum, and in such a manner as not to impede the entrance of the air into the cavity of the nose when the constrictor pharyngeus superior is inactive. Thus the patient can without any impediment breathe through the nose. But as soon as the constrictor contracts the cavum pharyngo-palati (this happens, as I will repeat for the sake of clearness, in the utterance of every letter with the exception of *m* and *n*), the muscle already named reclines against the vertical back surfaces of the obturator. By this operation the air-current is prevented from entering the cavity of the nose and is compelled to take its way through the mouth, and thus the utterance loses its nasal sound. To the existence of those vertical surfaces, and consequently to the thickness of that part of my palates which fills up the fissure in the soft palate and the cavum pharyngo-palatinum, I must attach special importance. But for that thickness the levator palati, when it rises upward, would not remain in contact with the side edges of the obturator, nor would the constrictor pharyngeus be able to effect a sufficient termination if the portion of the obturator nearest to it consisted only of a thin plate."

Fig. 974 represents the mouth without the apparatus.

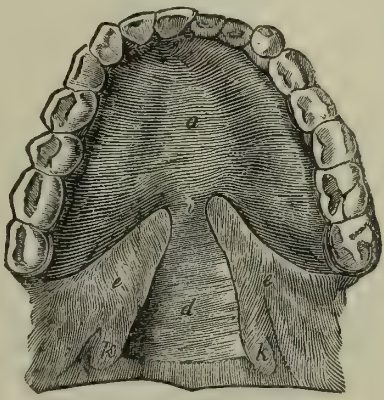
Fig. 975 shows the apparatus in position: Figs. 976 to 980 give various views of the appliance.

FIG. 974.



The Mouth without the Apparatus.

FIG. 975.



The Apparatus *in situ*.

The plate *a* and its narrow and thin apophysis *i*, which extends from the boundary *b* of the hard palate to the commencement of the defect *c* in the soft palate, serve also as supporters to the real thick obturator *d*. The latter lies in the pharyngo-palatine hollow, so that the lower

surface of the obturator turned toward the mouth is about on the same level as the rest of the velum palati, *e*. Against the vertical side *f* and

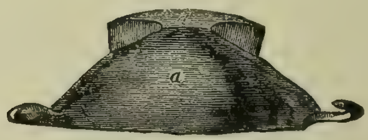
Fig. 976.

Side View of the Apparatus.

Fig. 977.

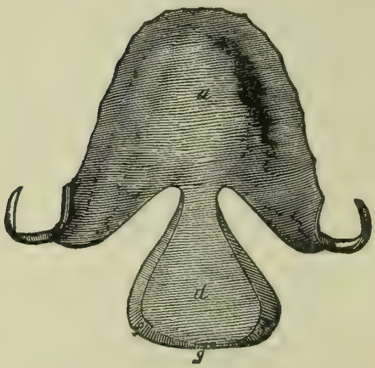
The Apparatus seen from the back.

Fig. 978.



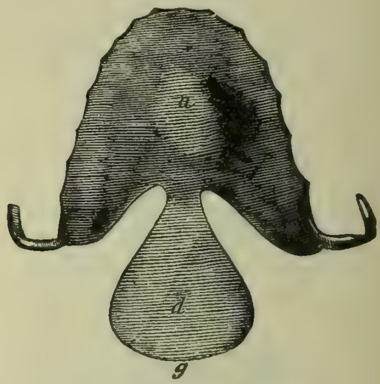
The Apparatus seen in front.

Fig. 979.



The Apparatus seen from below.

Fig. 980.



The Apparatus seen from above.

back edges *g* of the obturator the walls of the pharynx lean if the latter is contracted by a contraction of the superior constrictor of the pharynx. But if the muscle just mentioned is not in activity, the obturator does not touch the pharynx wall. The contraction of the constrictor superior therefore closes the valve formed, with the help of the obturator, between the cavity of the mouth and that of the nasal bone, while any relaxation of the above-mentioned muscle immediately reopens that valve. The thickness of the obturator begins where the fissure in the soft palate commences. With the high side edges *h* of the fore part of the thick obturator (which edges ascend, not straight, but obliquely, toward the outside), the side halves of the fissured velum palati *e* are in constant contact, even when the latter are raised by the action of the muscular levator palati. The proportions of the back part, which, in the same manner as in the case of an acquired defect, fill up the cavum pharyngopalati, *k k*, are the two halves of the fissured uvula.

Dr. Suersen admits the importance of the part taken by the levator

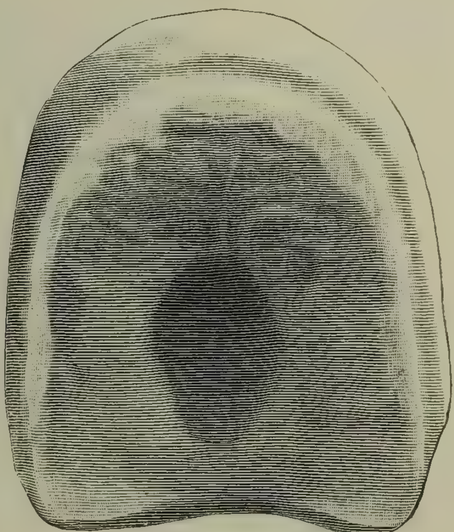
palati muscles in the formation of articulate speech; yet he makes no provision for utilizing them as such, and provides only for the contact of the superior constrictor muscle with the distal surface of the appliance to shut off the nasal passage. For the patient afflicted with congenital cleft to acquire perfect articulation with such an appliance (even if it be possible) years of application and training of this muscle would be necessary; and a little reflection will show that this muscle, besides performing its own function, must be trained to fulfil those of the velum palati, levator palati, and tensor palati. But in an *accidental* lesion this may be all that is necessary, as the patient having previously learned to articulate distinctly, and having this deformity come upon him afterward, the superior constrictor muscle would no doubt be sufficiently developed to perform that function. Sir William Ferguson, in his report of a dissection made by him of a cleft palate in 1844, states distinctly that the constrictor was very full, and he also claimed for that muscle very decided forward action in deglutition.

Dr. Kingsley, in speaking of Suersen's appliance, says: "First, that of all obturators this is the best form for a congenital fissure, but while the wearer is enabled to articulate with such an instrument, it is only after he has learned articulation with another apparatus. Second, that a soft, elastic, artificial velum is much better adapted to the acquirement of articulation than any unyielding, non-elastic substance, but when acquired an obturator may be substituted. Third, that in very rare cases articulation may be acquired with an obturator only, but it is the extra activity of the pharyngeal muscles, while with the elastic velum the levators of the palate contribute largely."

Simple Perforation of the Soft Palate.—A simple perforation of the

FIG. 981.

FIG. 982.



soft palate may be remedied by an obturator such as is seen in Fig. 981. This represents an appliance which will adapt itself to the constant movements of the soft palate. The body or main part of the apparatus is fixed by clasps to teeth in the mouth; the projecting or thickened portion B has a groove on both

sides into which the natural palate fits, the hinge-joint (A) permitting movement without any irritation from the appliance.

Simple Perforation of the Hard Palate.—Fig. 982 represents a simple perforation of the hard palate in an edentulous mouth, an ordinary plate of rubber, gold, or celluloid, which will cover the opening and fit accurately, being all that is required to remedy such a defect. In this case a rubber plate was supplied, a semicircular vacuum-chamber being made on each side to assist in keeping it in position.

FIG. 983.

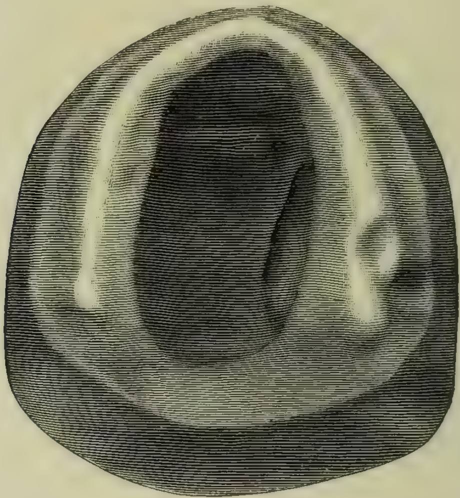
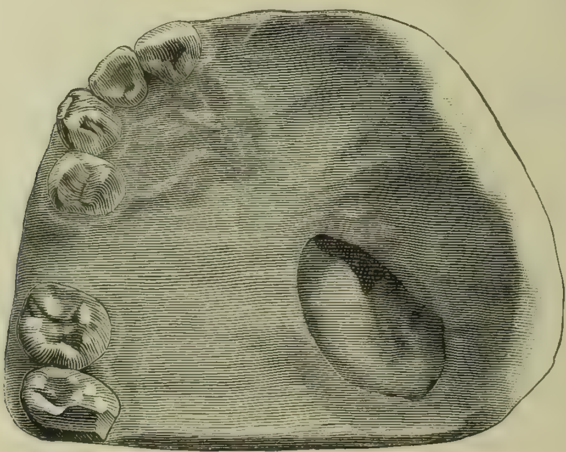


Fig. 983 is a similar case, the opening being more extensive.

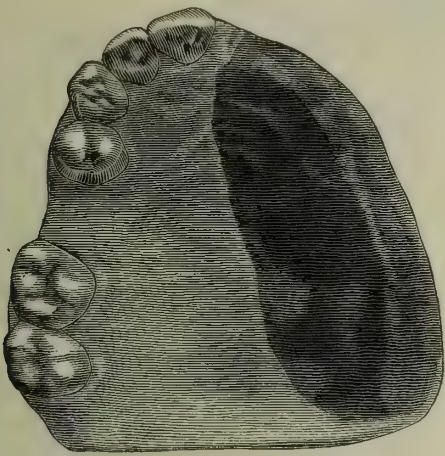
Fig. 984 shows a case in the practice of the writer in which a surgical operation had been performed, necessitating the removal of the

FIG. 984.



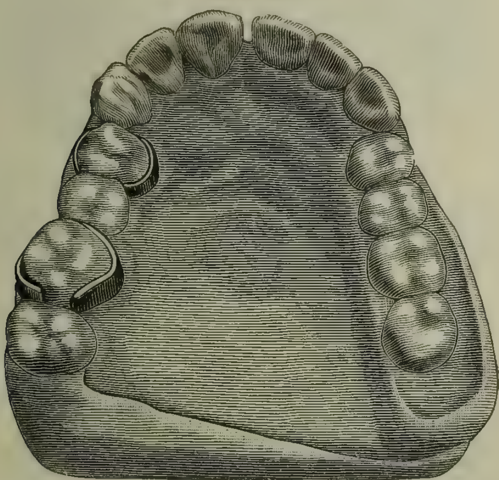
larger portion of the left superior maxillary bone, leaving an opening into the nasal cavity as seen in the figure. An impression having been taken and cast obtained, dies were made in the usual way. The shape of the mouth having been previously restored, upon the cast, in wax

Fig. 985.



(Fig. 985), a gold plate was made with teeth to supply the vacancies (Fig. 986). To keep the appliance in position more firmly a gold spiral spring was attached to a clasp fitting the lower first molar, as

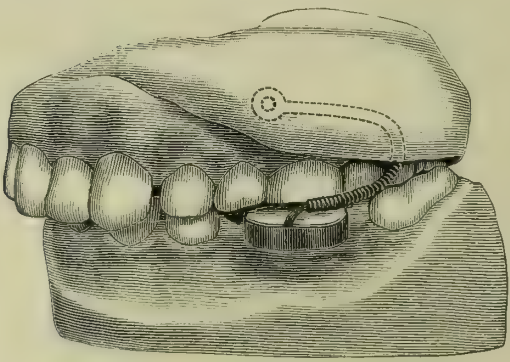
Fig. 986.



seen in Fig. 987. Upon the insertion of the appliance the patient's speech was completely restored and mastication accomplished without inconvenience.

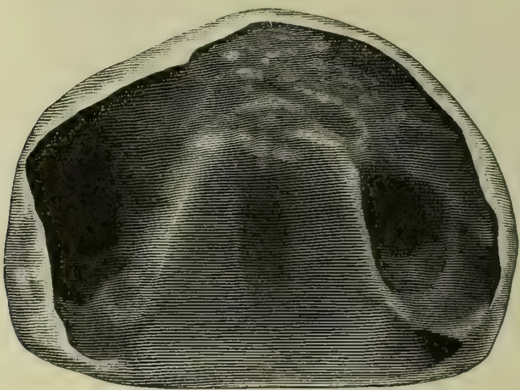
Fig. 988 is a case in the practice of the late Professor Buckingham, in

Fig. 987.



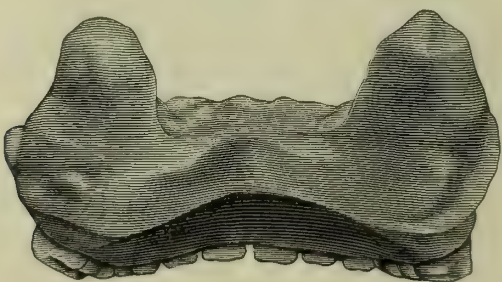
which there was no alveolar ridge, and the roof of the mouth was almost flat: there was also a large opening into the antrum on each side. To

Fig. 988.



remedy the case a celluloid plate with a complete denture was made, the plate having on the upper or palatal surface two projections, filling

Fig. 989.



the cavity in each antrum. The posterior view of the appliance is shown in Fig. 989.

Fig. 990 shows an obturator in position made by Dr. J. F. Preterre of Paris. It consists of a gold plate fitted to the teeth by means of

FIG. 990.

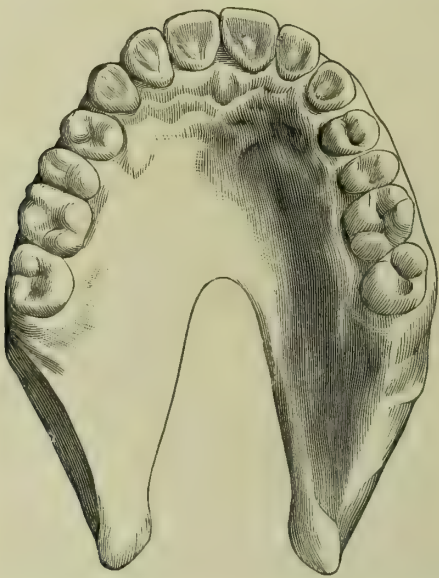
clasps, the bulb-like portion, which occupies the cleft, being hollow. The main objection to this plate, and one which limits its utility, is that it permits of no movement of its palatal portion, but merely fills the gap.

ARTIFICIAL VELUM OF HARD RUBBER.

Numerous experiments to provide an artificial appliance with hard rubber, utilizing the levator muscles to control the movement of the appliance, and with which articulation could be learned as well as with the perishable soft-rubber velum, resulted in the adoption by the author of the following device in cases where the cleft extends a little beyond the soft into the hard palate, as shown in Fig. 991. The appliance consists of a gold or hard-rubber plate (A, Fig. 992) covering the roof of the mouth down to the junction of the hard and soft palates. From this point the movable portion, F, extends back and downward, restoring the symmetry of the palatal surface by bridging across and lying

upon the muscles of each side. C E is a spring controlling the upward movement of F. The distal surface, G, or that portion coming in contact with the pharyngeal wall, is quite broad, and so constructed as to articulate perfectly with this surface, while the constrictor muscle con-

Fig. 991.



The Cleft, extending a little beyond the soft into the hard palate.

tracts and closes around it on a semicircle. This is the Suersen principle, and the main ideas are taken from that appliance.

The velum is of polished hard rubber, gold, or platinum, and much resembles a chestnut in form.

It is attached to the plate with a hinge-joint, B, B, thus giving free movement at the junction of the hard and soft palates. At the junction of the hard and soft palates there is a stop, which prevents any downward pressure upon the muscles when in a relaxed condition.

Fig. 992.

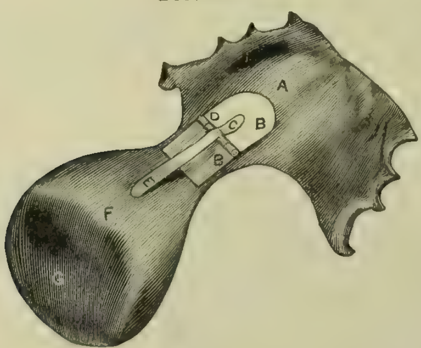
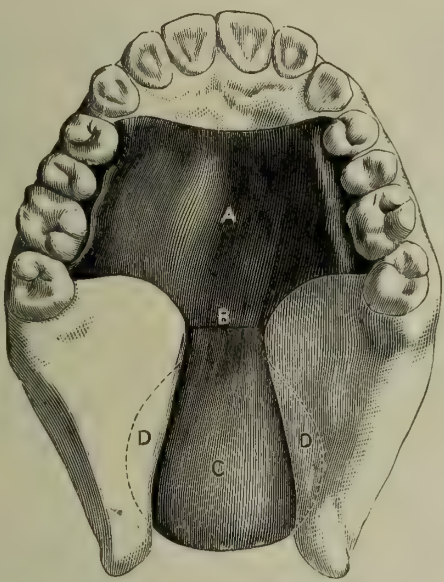


Fig. 993 shows the appliance in position, the dotted lines showing the part of the appliance resting on the muscles.

The main advantages of this appliance are—that it is made of a durable material, is easily constructed, and that articulation can be learned with it more readily than with any other appliance. In addi-

tion, it is so easily movable as to be acted upon by, and be under perfect control of, the muscles by which it is surrounded.

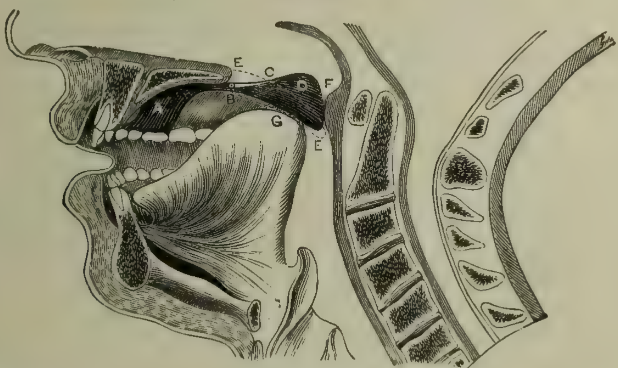
FIG. 993.



Appliance in position: A, the plate; B, the stop, preventing any downward pressure when the muscles are in a relaxed condition; C, the artificial velum; D, D, muscle lying under it, the dotted lines showing the appliance resting on the muscles.

In studying the mechanism of speech we learn that more than three-fourths of the sounds of articulate language depend upon the integrity of the soft palate for their perfect enunciation. This being the fact,

FIG. 994.



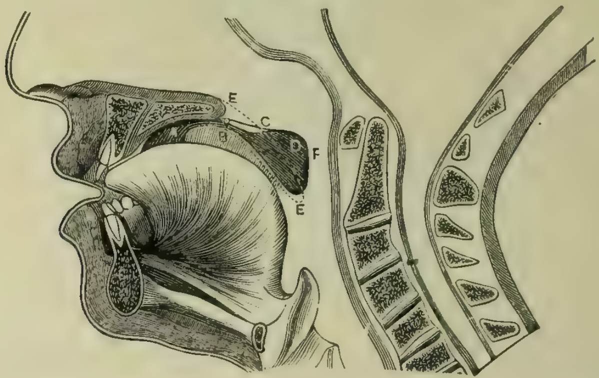
The artificial palate thrown up by the muscles. E, E, as in all sounds requiring the closure of the nasal passage; F, the superior constrictor muscle, advanced to meet it; G, the tongue, raised, pressing hard against the appliance, as in pronouncing the letter *k* or *g*; A, the plate; B, the hinge joint and stop.

articulation with a rigid obturator must be extremely difficult to acquire. If three-fourths of the sounds depend on the free movement of the nat-

ural palate, it seems a sufficient reason why provision should be made for the same movement in an artificial one.

Dr. Kingsley says that with a yielding appliance the levators of the palate contribute largely to correct speech. The surrounding muscles have control over the appliance here described in the following way: The artificial velum bridges across the opening and lies upon the muscles of either side. (See Fig. 993, D, D.) With all sounds requiring the closure of the nasal passage it is thrown up by the levator muscles, as shown at D in the sectional Fig. 994, there being no resistance. The thickness of the velum brings its posterior surface in close apposition with the superior constrictor muscle F, affording in the pronuncia-

FIG. 995.



The muscles relaxed, the appliance descended, thus giving a free passage for nasal sounds and respiration.

tion of the gutturals a firmer resistance to the pressure of the tongue G than can be obtained with a thin obturator. By the presence of the hinge B the above movements are rendered so free and facile that there is no tendency to displacement of the plate, such as occurs with a rigid appliance. If a nasal sound immediately follows a guttural, the descent of the velum is rendered certain by its own weight, even if not aided by the spring (Fig. 995, D).

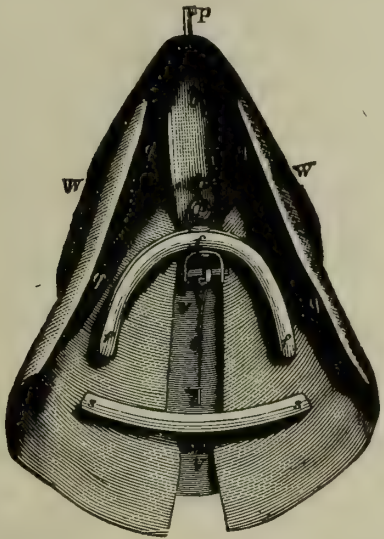
Artificial Vela of Soft Rubber.

Stearn's artificial palate was the earliest practical appliance introduced, though previous experiments had been made by others in the same direction. He made his first appliance in 1841 from a mould carved out of wood. His method was to take small impressions in wax of various parts and cut out their forms in the mould. Fig. 996 represents the palatal side of his instrument when complete; Fig. 997 the upper or nasal surface. *m m* is a piece of gold plate to be clasped to teeth on each side of the mouth. The groove *g g* is filled with the remaining part of the natural palate. The lower edge of the plate hung in the pharynx; contractile and other movements of the muscles were provided for by splitting the body of the plate through the middle; the opening thus made was covered with a valve or flap marked *v l v*, to

prevent sound escaping. The gold spring *f* (Fig. 997) retains the valve firmly against the body of the instrument. The bands *f f* and *s s* are

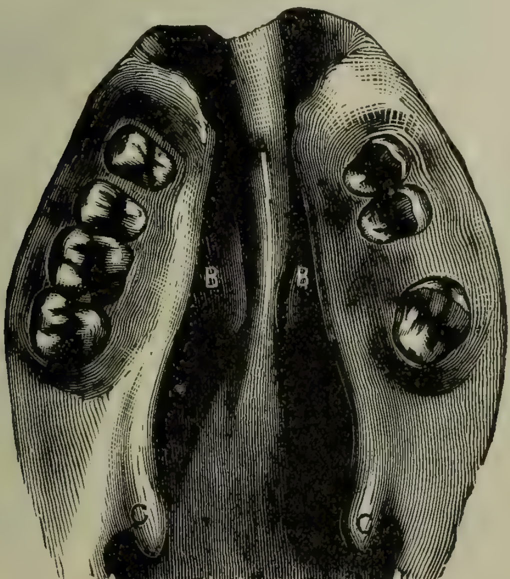
FIG. 996.

FIG. 997.



ridges in the rubber to give stiffness to the velum and assist in keeping it in position when contractile muscular force is relaxed. The

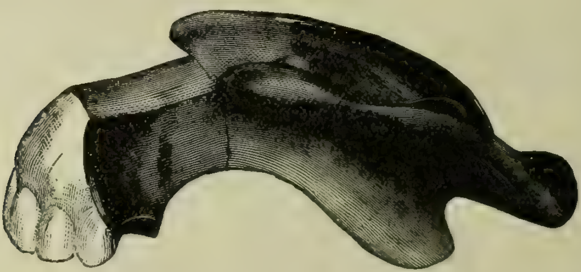
FIG. 998.



action of the velum when acted upon by the muscles in deglutition is that the sides *g g* lap over and slide upon each other very readily.

Kingsley's Soft-Rubber Velum.—In 1860, Dr. N. W. Kingsley came into the field and took up Dr. Stearn's appliance. Finding it too complicated for the general practitioner to construct, and too expensive when completed for those in ordinary circumstances, he was led to serious thought in regard to modifying its production, while still adhering to the same principle of utilizing the levator muscle. Respecting the Stearn appliance he says: "Two principles were vital to it—namely, first, that the artificial velum should embrace the levator muscles of the palate, so that it could be lifted by them; and second, that it should bridge the upper pharynx behind the uvula and cut off nasal communication at will." The result of Dr. Kingsley's operations with his illustrations are described by him as follows: "My plan began by obtaining a plaster impression of all the fissure and all the adjacent surfaces, resulting in the model shown in Fig. 998, in which A represents the disarticulated vomer; B B, the turbinated bones; C C, the divided uvula. I believe this to have been the first successful attempt ever made to use plaster of Paris for so extensive an impression. Upon the model I formed a pattern of gutta-percha, and copied it in hard rubber or vulcanite. This vulcanite model or pattern of an artificial velum was carefully finished, and steps were taken to make a mould in which to vulcanize

FIG. 999.



duplicates of soft or elastic rubber. Instead of the wooden mould of Dr. Stearn, I used type-metal, because of the ease with which it could be cast and the accuracy with which the parts could be fitted; and this I believe to be the first use of type-metal for this purpose. The result was an artificial velum of much nicer finish than could be obtained from wood, but naturally bearing the characteristics of the Stearn instrument.

"Subsequent experience with other cases showed me that the form then used, complicated with delicate gold springs, was objectionable; and my first effort at improvement was to do away with the gold spring which kept the central flap from drooping, and to sustain the flap by connections or springs of the same material. Such a change is shown in Figs. 1000 and 1001, which are drawings from an artificial velum made in 1863. Fig. 1000 represents the oral surface, and Fig. 1001 the superior or nasal surface. A A A represents the groove which corresponded to the border of the fissure. E E shows processes which lapped on the floor of the nares and assisted in its support. C is the central flap, same as used in the Stearn palate, and G G are the two bows

or springs of rubber which sustained it. In swallowing, the sides B B approached each other, sliding under the flap C. This instrument was made of soft rubber in a type-metal mould, the mould itself being an

Fig. 1000.

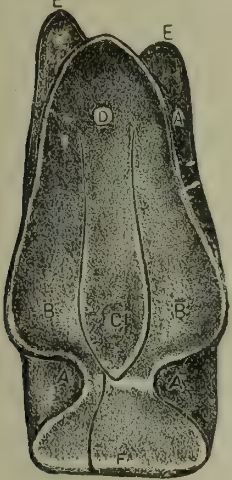
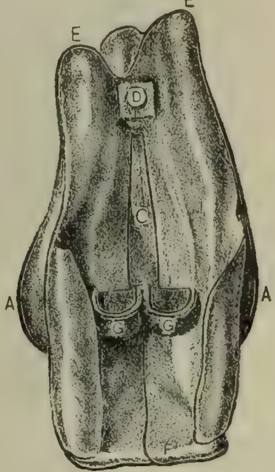


Fig. 1001.



intricate affair; but the instrument was simple in its application, and was of as much benefit in articulation as anything which has been produced since."

Still further modifications and improvements "consisted in abandoning the 'triple form' of Stearn, and doing away with the central slit, the flap, and all gold and other springs. These arrangements in the former appliances were to provide for the movements of the divided uvula and adjacent remnant of the palate. In deglutition the sides of the fissure are seen to approach each other, and in many cases come quite in contact." The simplified form consisted of two leaves of soft vulcanized rubber connected in the median line (Fig. 1002), the palatal portion (Fig. 1003, D) running down to the uvula, and then bridging across at that point, and the nasal portion (A) reaching across the pharynx. Instead of the appliance being made in sections that would slide across each other, as in the Stearn appliance, the bifurcated uvula slides between the two leaves, and the levator muscles of the palate lift it up to meet the pharynx, thus shutting off the nasal passage. It will be noticed that in this simplified form the Stearn principles are fully carried out, and to Dr. Kingsley the credit is due of perfecting and simplifying an apparatus which is almost universal in its application to cases of congenital fissure.

Fig. 1002.

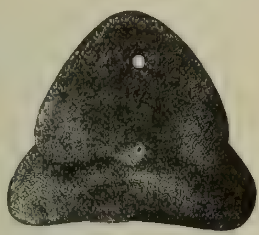
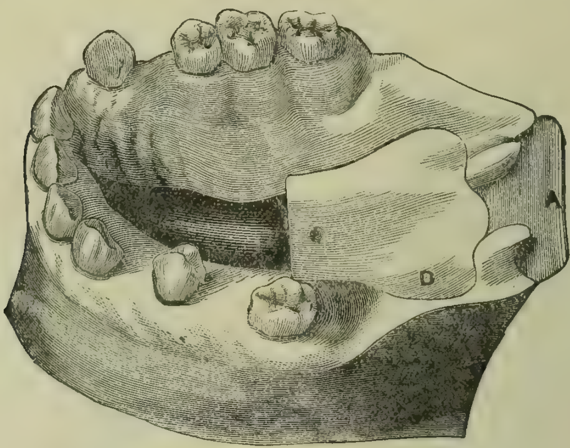


Fig. 1004 represents a case of congenital cleft in the practice of the writer for which a soft rubber velum was made, as shown in position, without the plate attached, in Fig. 1005. A side view of the soft-rub-

ber portion of the appliance is seen in Fig. 1006. The same case was supplied in 1872 with a velum and obturator combined, consisting of

FIG. 1003.

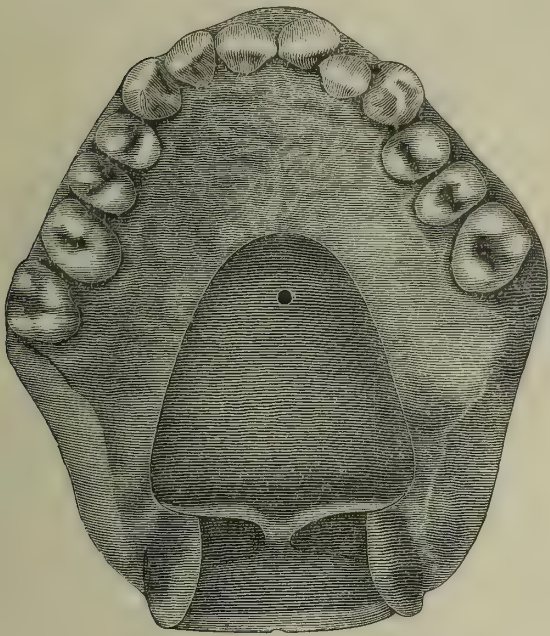


hard rubber: the palatal or upper surface is seen in Fig. 1007. The dotted lines represent the border of the fissure: A A is a flange on the

FIG. 1004.

plate and velum resting on the borders of the cleft; B is the upper flange of the artificial velum working on the hinge-joint opposite C; D is

FIG. 1005.



a flat piece of spring wire controlling the upward motion of B. Fig. 1008 illustrates the appliance *in situ.*

FIG. 1006.

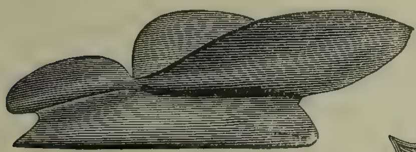


FIG. 1007.

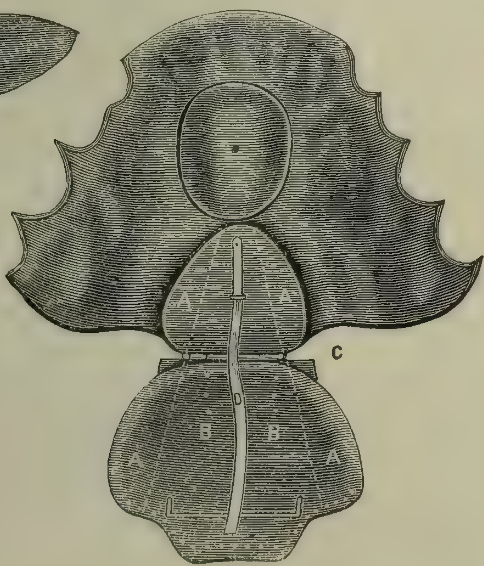


Fig. 1008.

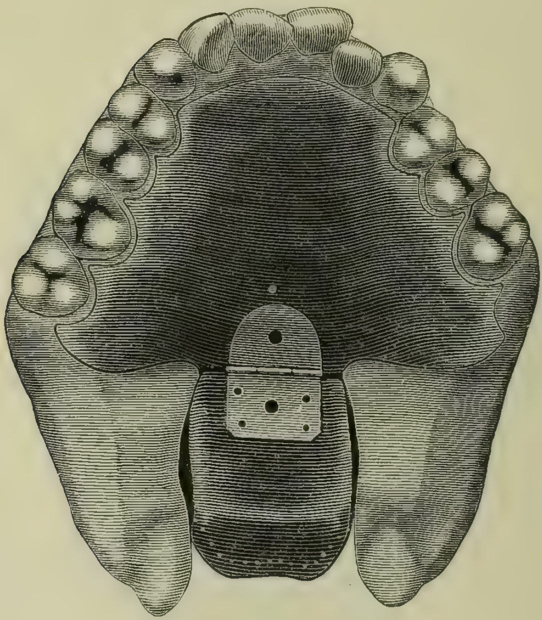


Fig. 1009.

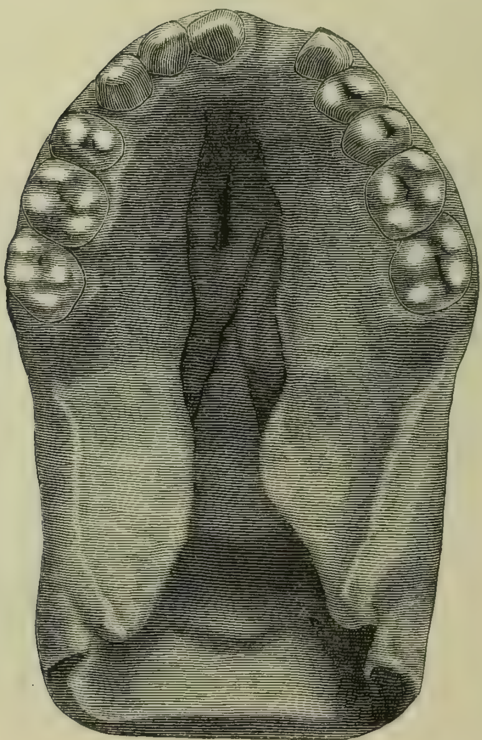


Fig. 1009 shows a case in which the fissure, extending from the alveolar process backward in the median line, had been partially bridged by a surgical operation. The appliance first made for this patient is seen in

Fig. 1010.

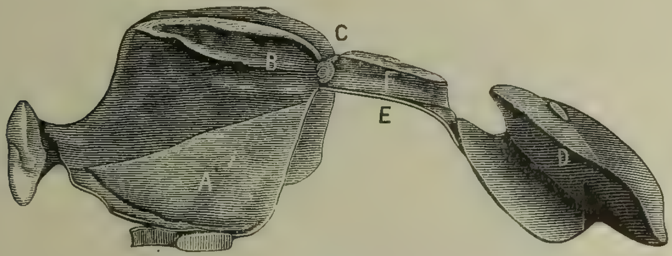
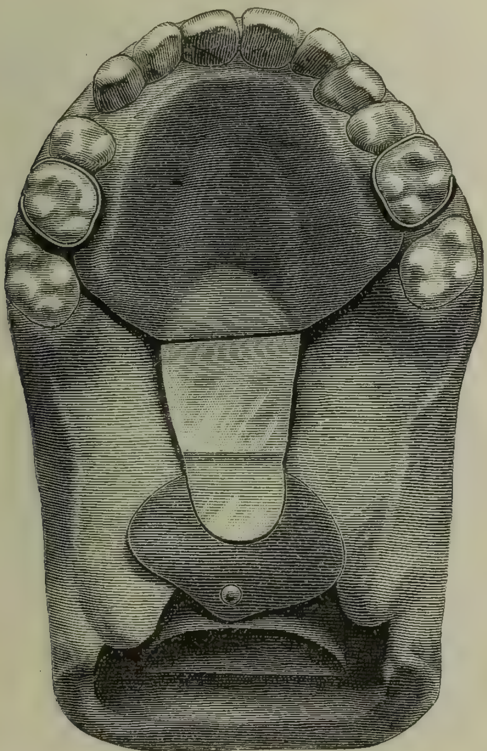


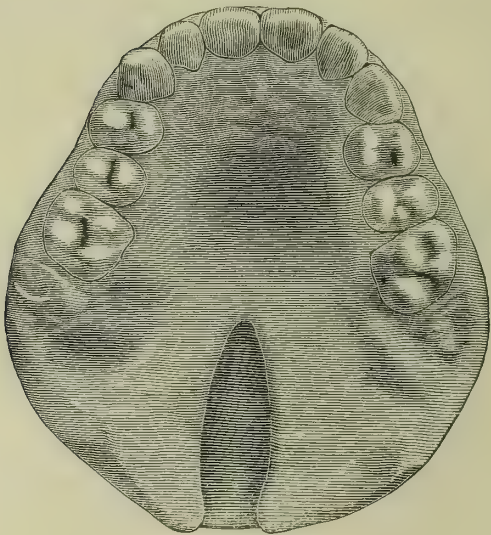
Fig. 1010: it consisted of a gold plate attached to the teeth by means of clasps, the artificial palate being made of soft rubber in two pieces, riveted together with gold pins after vulcanizing. A is the body of

Fig. 1011.



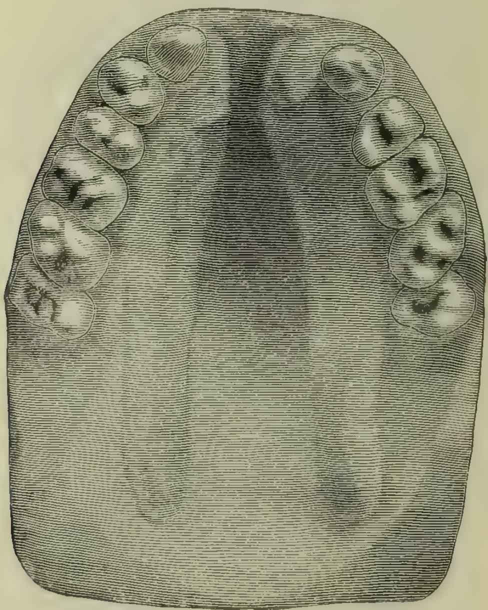
the plate; B, portion made of black rubber fitting the borders of the cleft in the hard palate; E is a projecting piece of plate working on the hinge-joint, C, placed at the junction of the hard and soft palates,

FIG. 1012.



and supporting the portion marked F, which is of hard rubber; also the soft-rubber palate, D. Fig. 1011 shows the appliance as it appeared in position.

FIG. 1013.



Owing to the rapid disintegration of the soft rubber in the above apparatus, the author determined to adapt his hard-rubber palate to the

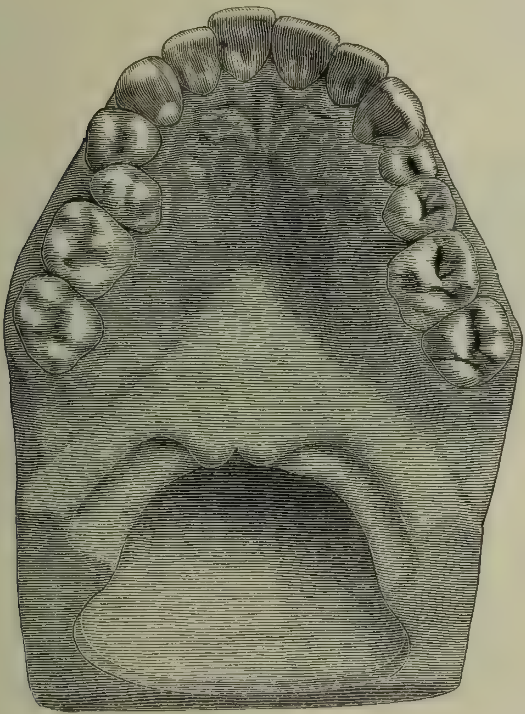
case. To accomplish this it was necessary to cut away the tissues previously united by the surgical operation. The improvement in speech attending the use of this appliance was so great that articulation was pronounced by experts to be faultless.

Fig. 1012 is a case in which the fissure was very narrow, but ability to speak clearly was as much impaired as in cases in which the opening is much wider. An appliance similar to the one supplied for the case illustrated in Fig. 1004 was successful in remedying the defect.

Fig. 1013 represents a case of double hare-lip, the fissure extending backward in the median line through the hard and soft palates.

Fig. 1014 is a rare case in which atrophy of both the hard and soft

Fig. 1014.



palates had occurred, there being no cleft. The soft palate was drawn up, and did not extend into the pharynx, having the same appearance as would result from staphylorraphy, though no such operation had ever been performed.

Examples of cases and of appliances used with satisfaction in their treatment could be multiplied, but all being varieties of the same thing, and consisting merely of a fissure or cleft of greater or lesser extent, and the most successful means of remedy having been shown in the foregoing pages, it remains only to describe the manner of making the appliances. Success depends on the ability of the practitioner to

apply to the case presented the most suitable of the various methods given.

Impressions of Cleft or Perforated Palates.

In making an obturator or appliance to supply a palatal defect it is of primary importance that a correct impression of all adjacent surfaces should be obtained, any appliance made from a bad impression being worse than useless, as instead of adding to the comfort of the wearer it has a reverse effect, and is apt to produce greater deformity. An adequate impression includes the palatal portions, alveolar processes, and any teeth which are in the mouth, and should be taken in plaster, as it is the only material which will not change its shape when withdrawn.

Fig. 1015 represents a plaster impression taken in an ordinary tray

Fig. 1015.

extended sufficiently with gutta-percha base-plate to meet the requirements of the case.

Dr. Kingsley says: "It is only when the floor of the nares is used for the support of the palate that it becomes necessary to obtain a more complicated impression—one which will represent not only a portion of the buccal cavity, but all the superjacent nasal cavity. When this is required the operation may be divided by first taking such an impression of the roof of the mouth and fissure as has been described, which we may call the palatal impression, and subsequently introducing the same impression again to get a further impression of the upper or nasal surface of the hard palate. This can be done by filling the cavity above the roof of the mouth with soft plaster down to the border of the fissure, and, while yet very soft, immediately carrying the palatal impression already taken against it, and retaining it in that position until the plaster is hard, which can be easily ascertained by the remains in the vessel from which it was taken. Taking the precaution to paint the surface

of the palatal impression with a solution of soap, to prevent the two masses from adhering when brought in contact, there will be no difficulty in removing it from the mouth, leaving the mass which forms the nasal portion *in situ*. With a suitable pair of tweezers this mass is easily carried backward and withdrawn from the mouth, the irregular surface of contact indicating its relation to its fellows when brought together.

"Fig. 1016 shows such an impression. The portion marked A B C will be recognized as that which entered the nasal cavity. The line of separation from the palatal impression is indicated in the engraving. The groove marked D shows the impression made by the delicate uvula in the soft plaster. The nasal portion is relatively large, showing an unusually large nasal cavity. The vomer lies between the projections marked A A, these projections entering the nasal passages. The surfaces marked B B came in contact with the middle turbinated bones; the surface marked C, in contact with the inferior turbinated bones. In many instances these turbinated bones are so large as to nearly fill the nasal passages."

FIG. 1016.

The author's method of obtaining an impression of the naso-palatine surfaces in cases of this kind is to first take an impression in an ordinary cup, using modelling-composition or wax: the former is preferable. This preliminary step gives a rough impression of all the parts, and from it a plaster cast is made on which to extemporize a cup to take a second impression in plaster. This cup is made by softening a sheet of gutta-percha in hot water and shaping it to the plaster cast. For a handle a piece of looped wire can be pressed into the gutta-percha while soft. This cup is made to extend a little beyond the uvula, and is bent up at the back to prevent any surplus plaster running into the pharynx when impression is being taken. A cup so nearly adapted to the parts as this requires only a layer of plaster from one-sixteenth to one-eighth of an inch all over it to obtain a correct impression. Care should be used in selecting plaster which is fine, quick-setting, and easily fractured, giving a clean break. It should be mixed quite thin, and be allowed to remain in the mouth until set, in the same manner as would be done in taking an ordinary impression. Before withdrawal care should be used to save and place in position all broken pieces from around the teeth or elsewhere.

This impression, if properly obtained, will show a distinct outline of the cleft and uvula. The portion of plaster occupying the fissure or cleft is next cut down to a smooth surface and a little forward of the median line of the cleft a hole is drilled through the cup and impression; in addition to this two pits are made in the smooth surface which represents the cleft, in the same manner as would be done in a cast for a "spider" articulator, to receive corresponding elevations in the second

half of the impression. The whole surface of the impression is then painted with sandarac varnish, vaseline, or solution of soap to prevent adhesion.

Fig. 1017.

The next procedure is to pass a rubber tube through the hole in the impression, replace it in the mouth, one end of the tube extending through on to the nasal surface, the other being carried forward and held with the cup in position by an assistant. In the outer end of the tube is placed the nozzle of a syringe (Fig. 1017) : a two-ounce vaginal syringe answers the purpose. After withdrawing the piston the required quantity of plaster should be mixed to the consistency of cream in a vessel with a spout by which it can be poured into the syringe. These preparations having been made, the assistant is instructed to hold the syringe in position, and the plaster is poured into it and the piston replaced. Slight pressure on the handle will force the plaster through the rubber tube on to the smooth surface and adjacent parts of the impression already taken, the patient being instructed to incline the head forward if the plaster is felt to be running down the throat, or backward if it runs too far in the opposite direction, the object being to keep it on a level if possible.

Precaution should be taken before the plaster sets to remove the rubber tube and syringe, and cleanse them thoroughly for future use. When the impression is ready for withdrawal, and it is not necessary for the plaster to set very hard, remove the lower or palatal portion with the cup; the nasal portion can be readily withdrawn afterward with a pair of tweezers in the manner described on p. 1081. The two portions on being put together will be found to fit accurately. Casts are obtained from such impressions in the ordinary manner, and if run with sufficient care the result will be a correct representation of the upper and under surfaces at each side of the cleft, and the borders will be distinctly defined.

The appreciation of the fact that a correct impression is of fundamental importance in making an appliance is sufficient explanation for the foregoing lengthy description of the manner in which they may be obtained.

Forming and Making the Velum.

The form of an artificial palate is determined after repeated trials with some plastic material which can be readily adapted to the required length and shape. The best material for this is gutta-percha base-plate, a trial plate being made upon a plaster cast obtained from the impression: the trial piece is extended until it approaches the posterior wall of the

pharynx. This will give the length of the palate. Dr. Kingsley says: "When the nasal portion of the impression does not indicate the superior surface of the soft palate, the part may be represented on the cast (model) by carving. It is not essential to the success of the artificial palate that the posterior surface of the soft palate should be represented with the same accuracy that is required on the inferior surface or on both surfaces of the hard palate. By the aid of a small mirror and a blunt probe the thickness of the velum and the depth behind the fissure can be ascertained; approximate accuracy is sufficient, since the portion of the artificial palate coming in contact with it is so elastic that it easily adapts itself to a slight inequality, rendering absolute accuracy less important."

The pattern to be made preferably of gutta-percha is seen in Figs. 1002 and 1003. The portion marked A in Fig. 1003, being subject to continual movement in its position in the pharynx, is made thin and delicate on all its edges, its sides being curved slightly upward and the posterior end turned downward. The palatal portion, D D, crosses the fissure at the base of the uvula.

"The end of the artificial palate should not come against the pharynx at a right angle, but rather obliquely. Consequently, if the palate is placed at a higher level, a shorter instrument will reach across; while, if it be placed at a lower level, a much longer instrument will be required. Both extremes are objectionable. The longer palate is liable to interfere with deglutition and to split and misdirect the column of sound in its outward passage, while the shorter one will affect the quality of the voice as well as make articulation more difficult. The best form is that which follows the border of the fissure from its apex down to the junction of the uvula with the palate, and then diverges across the pharyngeal passage, as seen in Fig. 1003. There is no difficulty in discovering the line of departure from the fissure; the uvula, which is bifurcated, or rather appears double, one on each side, is always strongly pronounced in its bulbous form, and its junction with the palate is always distinctly marked.

"When the fissure is filled or bridged across down to this point, the instrument here forms the superior boundary of the fauces, which theretofore was without boundary because of the fissure. Theoretically, it would seem that the artificial palate should stop at this point, and not continue at a different angle across the pharynx; but experience has shown the necessity for elongating it. The reason for this elongation is, that distinct articulation of the voice at times requires the passage of sound to be entirely cut off from the nasal cavity, while at other times the sound must escape in that direction. This cutting off of the nasal passage for sound is accomplished by the simultaneous action of two sets of muscles: 1. The levator muscles lift and in a sense carry back the artificial palate. 2. The constrictors of the pharynx bring forward or contract the pharyngeal wall. This is the physiological action of the palatal and pharyngeal muscles in the articulation of the voice. With an artificial palate filling a congenital cleft and terminating at the uvula, it will be found that when it is raised to the utmost power of the levatores, and the pharynx is contracted or brought

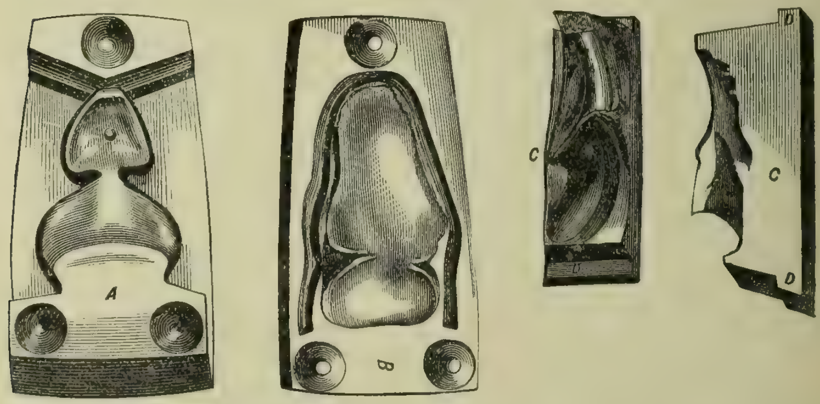
forward to its utmost, there is still a gap behind the instrument for the escape of sound, and for this reason the extension must be made. As an approximate guide for this length it may be stated that if the artificial palate is of the form described and placed in its best position, the palatal and pharyngeal muscles being all relaxed, there should be a space of about a quarter of an inch between its posterior edge and the wall of the pharynx. But the final test of this must be when the completed palate is introduced."[1]

When the ultimate form of the velum is determined, its duplication is similar to that of making an ordinary rubber plate. Such an appliance as Fig. 1007 being made entirely of hard rubber, details of the manner in which it is made are not necessary, as the flasking and vulcanizing processes are identical with those ordinarily employed in rubber-work. To make the velum of soft rubber requires more care and the process is much more complicated. The following is Dr. Kingsley's method:

"*Making a Velum of Soft Rubber.*—If plaster is used for the moulds, it must be worked so that the surface shall be free from air-bubbles, or the rubber palate will be covered with excrescences that cannot readily be removed. By covering the surface of the mould with collodion or liquid silex it will be much improved. But, ordinarily, plaster moulds will be found too troublesome for general use. They may be put to a most excellent use, however, by using one to make a duplicate of the gutta-percha in hard rubber. This is not necessary with those who have had much experience, but with beginners it will be difficult to work up the gutta-percha as nicely as may be desired; a duplicate in vulcanite will enable the operator to make a more artistic model of the palate, and one which can be handled with greater freedom.

"As, in the course of a lifetime, a considerable number of elastic palates will be required, the mould which produces them should be

FIG. 1018.



made of some durable material. The type-metal of commerce is admirably adapted to this use. A very complete mould is one made

[1] Kingsley's *Oral Deformities*, p. 296–298.

of four pieces, which will produce a palate in one continuous piece. Such a mould requires very nice mechanical skill in fitting all the parts accurately, and unless the operator has had experience in such a direction it is better to simplify the matter. Fig. 1018 shows a mould in four pieces. The blocks C C are accurately adapted to the body of the mould, marked A, and are prevented from coming into inaccurate contact with each other by the flanges D D, which overlap and rest upon the sides of the main piece: B shows the top of the mould, and the groove E provides for the surplus rubber in packing. Such a mould makes as perfect an appliance as can be produced. The palate is one homogeneous and inseparable piece. The cut will sufficiently indicate the form of the several parts. Each of these pieces is first made in plaster, having exactly the form desired in the type-metal. They are then moulded in sand, and the type-metal cast as in making an ordinary die for swaging. When in use, a clamp similar to Fig. 1019 is placed around the mould, to keep the several parts firm in their position.

Fig. 1019.

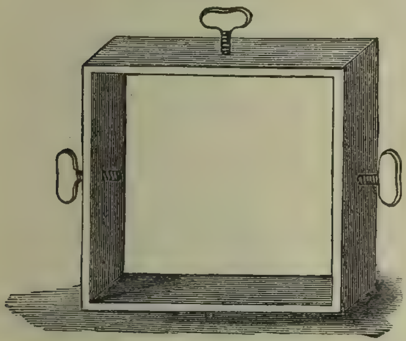


Fig. 1020.

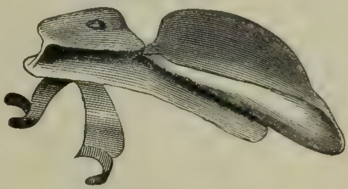
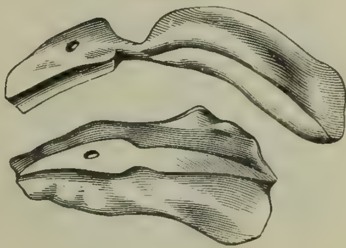


Fig. 1021.



"Fig. 1020 shows the palate complete, with its attachment to the teeth. The palate is secured to the plate by a pin of gold passing through a hole of the same size in the palate, the head on the pin being larger than the hole through which it is forced.

"By making the palate in two pieces, to be joined after vulcanizing, as shown in Fig. 1021, the mould may be made in only two pieces, and with very little trouble. When in use, the two pieces, as here represented, are bound together at the forward part by the gold pin before referred to; and a few stitches of silk secure it at the posterior part.

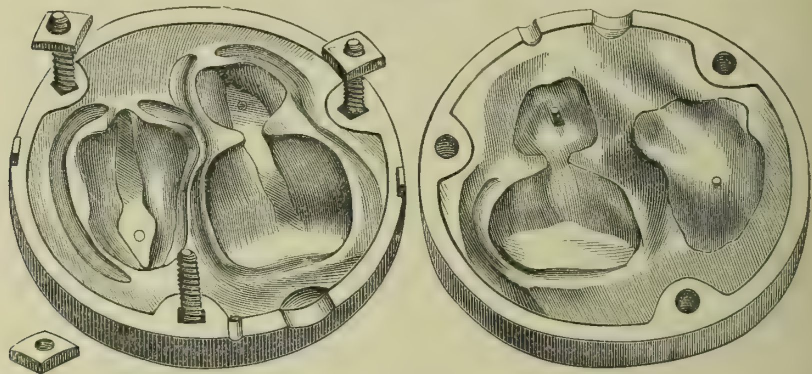
"The instrument then becomes identical with that shown in Fig. 1020.

"Fig. 1022 shows the mould or flask in which it is vulcanized. These flasks were made expressly for this purpose; but they are not so unlike the flasks in common use in dentists' laboratories that the

latter will not answer. The common flask is simply unnecessarily thick or deep.

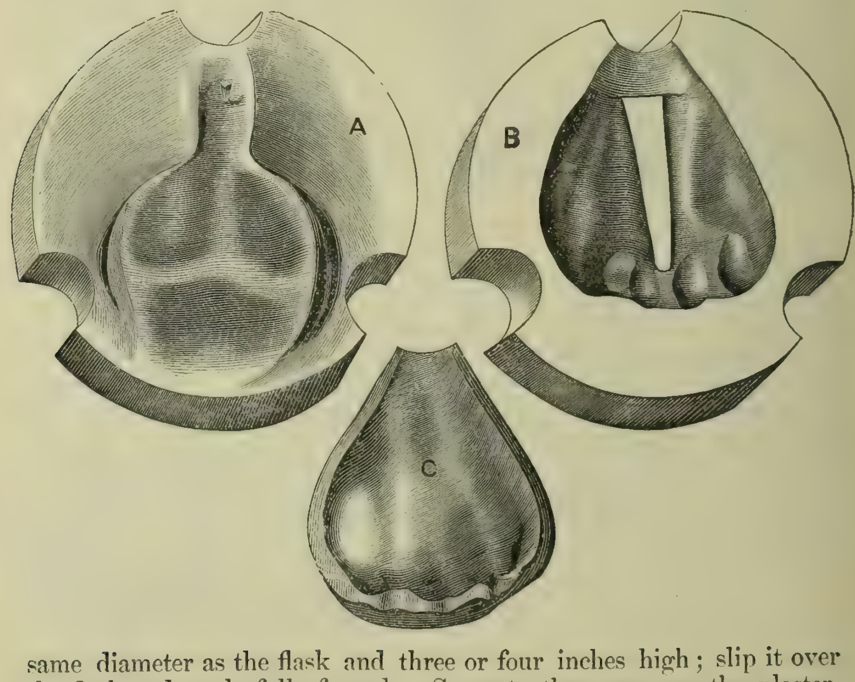
"The mould is readily produced in the following manner: Imbed the two pieces of the palate in plaster in one half of the flask; when

FIG. 1022.



the plaster is set and trimmed into form, duplicate it in type-metal by removing the palate, varnishing the surface, moulding in sand, and casting. In making the sand mould, take a ring of sheet iron of the

FIG. 1023.



same diameter as the flask and three or four inches high; slip it over the flask and pack full of sand. Separate them, remove the plaster, return the flask to the sand mould, and fill with the melted metal

through a hole made in the side or bottom of the flask. Having thus made one half, substantially the same process will produce the counterpart.

"Fig. 1023 shows the mould which produces the palate illustrated by Fig. 1003. It is the most simple, and at the same time the most complete, of any mould yet invented. The mould is made in three pieces, and is enclosed in a flask exactly the same as Fig. 1022, but with this improvement: the latter mould yields a piece formed of two separate parts of rubber, which must be afterward joined by stitching or otherwise, while the former (Fig. 1023) produces an appliance in one piece, and as perfectly finished as by the more complicated mould of four pieces shown in Fig. 1018. Letter A represents the base of the mould; B, the middle section, which is placed on the top of A; and the third section, or top, C, completes it.

"The mechanical processes by which this mould is made are substantially the same as given for making those before described. The packing of the mould with rubber should be done in the same manner as when hard rubber is used for a dental base, with which process it is assumed that the reader is familiar. By washing the surface of the mould with a thick solution of soap previous to packing, the palate will be more easily removed after vulcanizing. The rubber used for this purpose must be a more elastic compound than that for a dental base-plate. The composition used for the elastic fabrics of commerce will answer if made of selected materials. There is also on sale at the dental dépôts a soft, elastic compound admirably adapted to the purpose, with accompanying instructions for vulcanizing; the best results being obtained by heating up to 230°, and gradually increasing, during four or five hours, to 270°."[1]

Adjusting the Velum to Position.—Dr. Kingsley, describing the size of the artificial palate and the method of placing it accurately in position, says: "It is not necessary that the artificial palate should come to the apex of the fissure if the apex be within the hard palate; neither is it absolutely essential that it should reach completely to the apex if the fissure comes no farther forward than the posterior margin of the hard palate. But, if the fissure is short and does not come up to the palatine bone, it is better that the artificial palate fill the fissure to the apex. At all events, it must be broad enough to cover all of the remnant of the soft palate on each side of the fissure and anterior to the uvula. Place the palate in position on the plaster model, and proceed to make a temporary plate or attachment for the purpose of trying the palate in the mouth. A very easy method is to insert in the hole in the palate a bit of common iron wire of suitable size to fit into it, with the end on the oral side bent toward the front teeth. Pour a little plaster over the gum, as represented in the model, about this wire, and reaching back to where it is inserted in the palate. When this is sufficiently hardened it can be removed, and will prove a convenient way of trying the palate in the mouth and proving its position previous to a more permanent and less alterable attachment. It may sometimes be found that, with all the

[1] From Harris's *Principles and Practice of Dental Surgery*, pp. 981–984.

care and skill used to prove the plaster model correct, when the artificial palate is tried in some variation of its position or hanging may be desirable. If on trial the only change desired be the pitch—either to raise or depress it at its posterior end—this can be readily done by bending the pin as it appears out of the plaster. But if it requires to be drawn farther forward or carried farther back, it will be more satisfactory to reset it on the plaster model and make a new plaster trial-piece as before. This latter process, which may be termed *hanging the palate*, is of equal importance to any antecedent step, as it is quite possible to have an instrument made with the utmost nicety of workmanship, and yet so unskilfully applied as to be of little or no service to the patient.

"The final security of the palate must be of course by some connection with the teeth, or, in the absence of natural teeth, with some plate bearing artificial teeth. An excellent way of arriving at this result after the hanging of the palate is determined is as follows: Instead of the pin of common wire which has been used with the plaster trial-piece, make one of gold wire of the same size, with a head upon it. Put the gold pin through the palate with the head on the nasal or upper side, and bend the pin at nearly a right angle where it comes out of the palate on the oral side, pointing it as before toward the front teeth. Proceed as before with the plaster trial-piece, and when satisfactory pull the palate off the pin, replace the plaster trial-piece in the mouth, and take an impression in plaster of it and all the parts desired outside of it. When this impression is removed, the gold pin will be found standing out of it in the exact position in which it is desired to hang the palate. Make a cast into this impression, and the result will be that the pin is transferred to a model which represents in plaster the face or oral side of the artificial palate and all the adjacent gum and teeth. From such a cast as this there will be no difficulty, to the ordinary master of the details of the laboratory, in making the attachment. Such a plan as here described will be found more especially applicable to a vulcanite or celluloid base. If these materials are used the steps are quite simple. The cast represents the whole surface with which the plate is to come in contact, with the pin in position and bent so as to become anchored in the plate. If the precaution has been taken to *flatten* the gold wire at the end, it will make the anchorage more secure. Upon this cast and over this wire the form of the attachment or plate will be worked up as is usual in making a plate for artificial teeth, and the subsequent steps will also be similar.

"Experience has shown that in a considerable number of cases the pharynx will not at first tolerate so large an appliance without irritation as it will subsequently, or so large as will best secure the desired results. Consequently, it is better to introduce an instrument with a smaller pharyngeal portion. This posterior or pharyngeal part of the instrument can be reduced in size by cutting it down with a pair of scissors; but this leaves the edges thick and more or less irregular and ragged, and such a course is therefore objectionable. It will be borne in mind that the pharynx is made up of muscular tissue covered with

a delicate membrane, which becomes excited to action upon contact with foreign substances, and the first effort will naturally be one of contraction, as in the process of swallowing. These spasmodic movements in some are slight and of temporary duration, while in others the vain effort to swallow the offending mass becomes uncomfortable. If now the pharyngeal portion of the artificial palate be reduced in size by cutting, the thick and harsh edges may cause irritation. It is better, therefore, to make the instrument for the first introduction with the pharyngeal part reduced in size as it comes from the mould, thus having the thin and delicate edges which are so desirable for comfort, and equally so in the selection of a palate already made: the choice of the first is better to be one which fills the fissure fully as it is desired, but one with a smaller pharyngeal extension than will be ultimately required. With an instrument of suitable materials and properly adjusted it will be but a few days before it is worn with ease, and in a very little time its removal will be a positive discomfort.

"The final length of the posterior extremity will depend much upon the activity of the muscles of the pharynx. There is a great difference in the power or control of the pharyngeal muscles, as shown by different individuals. In some the action of the constrictors is very great, while in others there is, even in deglutition, apparently but little movement. Upon the introduction of the completed palate the action of all the muscles concerned can be observed, and thus the length at which the palate shall be finally left can be determined.

"In a case where the pharyngeal muscles are in a very passive state, some calculation can be made upon a cultivated activity in the future, for upon their action and control will depend, in a large measure, the improvement in speech. The Suersen obturator depends entirely upon this pharyngeal action for its success, but it is only in exceptional cases that they can be educated to the duty otherwise required of both them and the palatal muscles. It will generally be found that as the patient makes progress in the articulation of the voice a shorter artificial palate can be worn, and one which comes nearer to the length of what the natural palate would have been if not deformed.

"The durability of an artificial velum depends much upon the cleanliness and care of the wearer. In some mouths the fluids act upon the soft, elastic rubber, and it becomes deteriorated much sooner than in others. In some instances patients have worn one for several years, while others will use one up in a few months. Dispensing with it during sleep and thorough cleansing frequently with hot water do very much to prolong its usefulness; and this necessity for cleansing should be impressed upon the patient's mind."[1]

Making a Velum of Hard Rubber.—The disintegration of soft rubber when worn in the mouth is the principal objection urged against its use. Recognizing this, the author devised the appliance shown in Fig. 1007, which is made entirely of hard rubber. It is not essential in the making of an artificial velum of hard rubber that the plate should extend farther forward than the cuspid or first bicuspid teeth, or that it should extend farther back than the second molar, unless there are vacant spaces which

[1] Kingsley's *Oral Deformities*, p. 306.

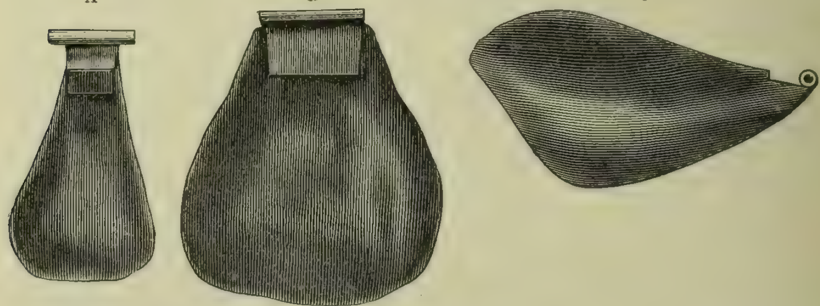
it is desirable to fill. It is necessary, however, that there be one good tooth (molar preferred) on each side, to obtain steadiness for the appliance by means of clasps. These must be accurately fitted to the teeth and be made of the best clasp-metal. Where the teeth are short and cone-shaped, and clasps are not readily retained, a portion of the metal, about one-eighth of an inch wide and of the same length, can extend beneath the gum between the buccal roots of molars. This should be fitted closely and conform to the depression above the neck, and have a rounded point and sharp edge to slip under the gum without irritating it. A clasp made in this way retains a plate very firmly, the projections acting as spurs. They have been used for a number of years without any detrimental effect from wear or decay upon the teeth.

The hinge-joint marked B B in the same figure should be from three-fourths to an inch in breadth, and when fixed in position should be placed about a fourth of an inch from the junction of the hard and soft palates, even if the cleft is quite narrow. If the cleft does not extend to the hard palate, there should be a tongue from the joint into the fissure for the attachment of the bulb. The joint is made in three parts—two ends and a centre; the centre part of the hinge should be the widest. The tongue to which the bulb is attached, and which extends into the cleft, should be only the width of the cleft, and when fitted to the required size must be soldered to the centre piece of the hinge. The hinge, as already explained, is provided with a stop (see C, Fig. 1024) which checks the downward movement of the bulb.

The mode of forming the bulb-like portion of the appliance illustrated in Fig. 992 is to first obtain a model of its required form in gutta-percha or some plastic material. The principal objection to gutta-percha is that it cannot be finished with a perfectly smooth surface. Paraffin wax is much preferable, as when warm it is readily moulded with the fingers, and when cold can be carved and finished until quite smooth. When moulded in the shape of a chestnut it is attached

FIG. 1024.

A B C



to the gold tongue which extends into the cleft and is then introduced into the fissure, the sides being pressed up so that the levator muscles will slide under to lift it into place. The bulb must be perfectly adapted to all its surrounding parts, and the centre of the lower or palatal surface along the median line should be on a level with the levator muscles. Repeated

trials and the most careful and delicate manipulation are required in shaping the bulb to fit the fissure accurately. Two forms of bulbs, with the centre part of the hinge attached to the gold tongue, are seen in A and B, Fig. 1024. C is a side view of the bulb B, showing the slot in the hinge-plate which forms the stop.

To reproduce in vulcanite the form of the bulb, which, to avoid undue weight should be hollow, an ordinary flask can be used. The form is placed in the lower half of the flask palatal side down, the plaster being trimmed evenly all round and the exposed part of the tongue secured so as to retain it in proper position. After varnishing, the upper part of the flask is filled with plaster and allowed to set until ready to separate, as in making an ordinary rubber denture. Next remove the wax or gutta-percha—whichever is used—in any convenient manner. If when the wax is removed the gold tongue is not already within a sixteenth of an inch from the lower surface of the mould, it should be bent to that distance, so that when vulcanized it will be firmly imbedded: it should also have a hole punched through it to more securely hold it in position. In bending great care should be used to prevent disturbing any other part of the tongue. The sheet rubber is next cut into sections, which when joined will fit as nearly as possible the part occupied by the wax. The edges of these sections should be moistened with chloroform when fitted together, thus forming a sac, into which a few drops of water should be placed before sealing the last piece. By this means the steam formed inside the sac during the process of vulcanizing will, if the sections have been tightly closed, force the rubber into the exact shape of the mould, and an appliance be obtained so light that it will float upon water, and when in use will readily be acted upon by the slightest movement. When vulcanized this is polished in the ordinary way, and attached to the plate by means of a wire through the hinge-joint, platinum wire being the best for this purpose.

Nasal and Maxillary Prosthesis.

The accidents and diseases to which the nasal and buccal organs are liable make desirable a knowledge of the manner by which they can be replaced. Though each case is in itself unique, a few examples of cases which have been successfully treated will suggest ideas of apparatus which can be applied with such modifications as will be required by the judgment and knowledge of the operator.

Fig. 1025.

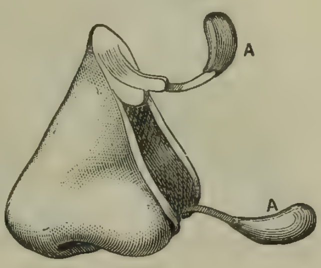


Fig. 1025 represents an artificial nose, with the means employed to hold it in place. The parts A A are of vulcanite, attached to the main part of the appliance by flat gold springs and fitting into the nasal cavity. The principal objection to this manner of attachment is their liability to cause irritation, resulting in inflammation or absorption of the tissues. A better plan for holding the piece in position is

by means of spectacles instead of the upper spring. These if properly adjusted prevent all movement, and at the same time conceal the line of demarcation.

The method of making such an appliance as figured is to first obtain an impression in plaster of the face, from which a cast is made. Upon this is modelled in wax of a flesh color the form of the artificial nose. This is carved to the shape desired: the color of the wax being uniform with the surrounding tissues enables the operator to attain a better effect. The exact shape having been determined, the inside of the model is hollowed out and casts or dies made upon which to complete the work. Dies are preferable, as the piece can then be duplicated at any time without the details of remodelling.

The different substances used for making artificial noses are wax, celluloid, wood, porcelain, and vulcanite. Though much objection has been raised to the last-mentioned substance, it is often preferred on account of lightness, strength, rigidity, and slight liability to injury. After vulcanizing the piece it is finished in the usual way, and the surface painted in oil colors to imitate the flesh as naturally as possible.

An example of a case in which a nose, lip, and obturator were combined was presented to a meeting of the Pennsylvania Association of Dental Surgeons, and reported in the *Dental Times*,[1] as follows:

"The case referred to by Dr. Hoopes was one treated by him in the year 1860, and published at that time in the *American Journal of Dental Science*, an abstract of which is here appended: H—— R——, aged forty, had enjoyed good health until about fifteen years ago, when he contracted primary syphilis. Four years subsequently the disease, in a tertiary form, attacked the internal surface of the nasal bone, and continued to spread for some five years, when fortunately its progress was arrested, though not until it had committed the most terrible destruction of the bones and soft parts of the face. Fig. 1026 inadequately presents the appearance of the face. It may be better understood by a description.

Fig. 1026.

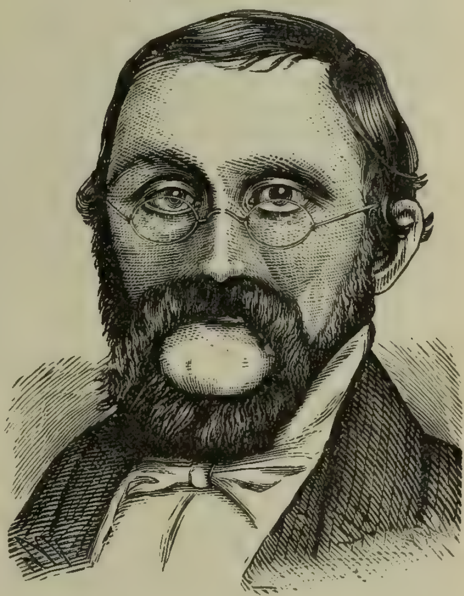
"The lower margins of the nasal bones are destroyed, with the entire vomer, the nasal cartilage, and a portion of the septum. The left inferior turbinated bone is gone, and a portion

[1] *Dental Times*, January, 1864.

of that of the right side. The anterior portion of the malar bone is destroyed on the left side, nearly reaching the antrum; also the superior alveolar process, leaving a mere rim, with three molar teeth on one side and two on the other. The central portion of the palatine bones is also gone, leaving an open space about the size of a half-dollar piece. Of the soft parts the destruction has not been less extensive. The upper lip is destroyed, except at the angles of the mouth, and ulceration had taken away much of the soft tissues of the posterior nares. The muscles of the upper lip and face that are partially destroyed are the orbicularis oris levator, labii superioris alæque nasi, and on the left side a part of the zygomatic and levator anguli oris. It should be remembered that the sketch given reverses the side of the face.

"On looking inward and downward, the parts presented a deep, large cavity; the motions of the uvula could be seen by looking into the nose, and the tongue closed the opening through the palatine bones. Of course, speech and deglutition would have been impossible had not the patient continually kept a large piece of raw cotton in this opening. The lower lip had also begun to suffer the ravages of the fearful disease, but it was arrested at this period, and this lip presented an enlarged appearance from the healing of a large granulated surface.

Fig. 1027.



"The first step in the process of making a mechanical contrivance to hide this hideous deformity was, to make a cast in plaster of the anterior portion of the face, and another of the mouth. A gold plate was then made, fitting the roof of the mouth, and upon this were inserted all the teeth that were deficient, and this plate was clasped to the remaining molar teeth. A model of an artificial nose and upper lip was then made, as near the natural form as possible. A cast of this model was filled with hard rubber, which was then vulcanized. A gold bar was attached to the inside of the artificial nose, which was made more firm by a cross-bar. The opening through the palatine bones gave an opportunity to secure the nose to the plate; this was done by attaching a short tube to the plate and passing the bar through it. The plate was then placed in the mouth, the nose was attached to the face, and the bar was passed through the tube, which held it firmly in position. The stiff, unnatural appearance of the upper lip was hidden by a heavy artificial moustache. The connection between the artificial and

natural nose was concealed by the bow of a pair of spectacles. The artificial nose was then given a lifelike color, and the illusion was complete.

"This appliance so fully answered the purpose that the wearer had, at subsequent times since its introduction, assured him that it was perfectly priceless, and that he felt, if possible, like a new man."

The following interesting case, from the practice of Dr. C. A. Brackett of Newport, R. I., furnishes another example of facial, nasal, and palatal defect combined:[1]

"C. P. M——, now aged about thirty-five years, was much disfigured about four years since by the ravages of secondary syphilis, losing a portion of the upper lip, the entire nose, including the turbinated bones, and both the hard and soft palates, making of the nasal and oral cavities one vast chasm, and the face almost perfectly flat. The man is a mason by trade, and has a large family dependent upon him for support. In his disfigured condition he found it difficult to obtain employment. Indeed, he looked so repulsive that the city marshal of the place where he has his residence had been petitioned to have him confined in some institution.

"Being consulted in the case, I consented to try to do something for the improvement of his appearance.

"The syphilitic ulceration having been cured, there seemed to be no reason why artificial appliances might not be introduced. An artificial velum was precluded by the complete destruction of the palatal muscles, so that there were no means of supporting and moving such a contrivance. Hence I confined my efforts to making an inflexible obturating plate and substitutes for the external parts.

"In the arch were several loosened teeth and diseased roots. These I removed and waited for the healing of the parts. The cuspids, first bicuspids, left lateral incisor, also the left second and third molars, were in comparatively healthy condition. The preservation of these was most important for steadying and in part supporting the plate, it not being possible to render atmospheric pressure of avail for that purpose. An impression of the parts to which the plate was to be fitted was taken in wax. The obtaining of a good impression was very difficult, the mouth being narrowed and the lips bound down with cicatricial tissue. The cup used was barely wide enough to enclose the teeth. Upon its posterior edge was riveted a plate of German silver, to increase its length. To get the impression from the mouth required considerable force after the wax had been made rigid with ice and the portion projecting into the open space enclosed by the arch had been cut away. On a model from this impression a pattern plate was moulded and the bite taken in the usual way.

"The obturator was made of ordinary vulcanite. It fitted the alveolar border, supplied the place of the hard palate, and extended back to within about one-half inch of the posterior wall of the pharynx. I should have preferred to have left a rather smaller opening at the back, but the plate was as long as could be made in the largest flask to be found. In front the missing incisors were replaced with plain artificial ones,

[1] *Dental Miscellany*, May, 1874.

and the gum was imitated with pink rubber. The plate was closely fitted to the remaining natural teeth, but had other means of support, to be explained directly. Care was taken that pressure applied to a tooth in any direction should be duly counterbalanced.

"In modelling the pattern for the nose I was greatly assisted by an impression of a nose which I was told resembled the lost member of the patient. This pattern was accurately fitted to its place on the face, and

Fig. 1028.

Patient as Disfigured by Disease.

Fig. 1029.

Patient wearing Appliances described.

then copied in vulcanite. Projecting from the centre of the lower part of the nose, close to the remains of the upper lip, was a steel pin, made to enter a small hole drilled on the mesial line in the artificial gum of the plate. Vulcanized in the upper surface of the obturator, about midway of its length, was a gold eye or staple, to which was fastened one end of a spiral spring of platinized gold wire a little more than an inch in length. Upon the opposite end of this spring was a small gold hook to fit another staple in the posterior extremity of the artificial nasal septum. The plate being put in place and the spring brought to the opening left by the destruction of the natural nose, the artificial nose was attached by means of the hook and staple, and all the appliances were held very firmly in position.

"The nose was painted by an artist to match the skin of the face, making it a very good counterfeit of a nose of flesh. To conceal the deficiency in the upper lip, as well as the external connection between the false gum and nose, an artificial moustache to match the beard was procured of a professional hair-worker. This I attached to the front of the artificial gum with some small watch screws, also supporting it in the centre with a loop around the steel pin. This arrangement the patient has since improved upon by moulding a piece of tin to fit over the place where the moustache should grow, sewing to it the artificial moustache and attaching the whole to the central pin.

"The appliances were put in place January 16, 1874, and the woodcuts are from photographs taken at about that date. The substitutes have since been worn constantly with comfort and to the satisfaction of the patient and his friends. His speech is improved, he has no trouble in eating, and he prefers to sleep with all the apparatus except the moustache. He is able to remove and reapply the mechanism very quickly and without assistance. His principal annoyance is from the secretion of the inflamed mucous membrane when he has a cold, the artificial nose not being quite so convenient to 'blow' as the natural organ."

Dr. Brackett states that "at this date (1887), after the lapse of more than twelve years, the patient is still wearing the substitutes with comfort and satisfaction. In the interval of course a number of repairs have been needed, but many of them have been of a minor nature, such as the patient could accomplish for himself."

Fig. 1030 illustrates the appearance of a patient supplied with an appliance by the late Prof. E. Wildman.[1] The parts destroyed by disease consisted of the entire external nose, the nasal bones, nasal processes of the superior maxillæ; also a large portion of their palatine processes, the proximal parts of the palatine processes of the palatine bones, and the turbinated bones. The soft palate, the uvula, and tonsils were uninjured. In looking into the nasal cavity, the walls of the antrum on the left side were found deficient, and ends of the roots of the incisors were exposed and decayed. The tongue was visible through the opening in the palatine arch. The size and shape of this orifice are represented by the outer central line in Fig. 1031.

Fig. 1030.

The Face without Nose.

"A first step in the operation for remedy was to procure an impression that would secure a perfect model of all the parts involved, and their surroundings, in their relative positions. For this purpose plaster was first used, but, its use being precluded by the acrid secretions in the nasal cavity, wax and paraffin were substituted. Owing to the rigidity of the upper lip, Dr. Wildman was unable to employ the ordinary impression-cup with success, and found himself obliged to take a rough impression of the palatine arch, from which a model was made and a metallic impression-cup swaged.

"A sufficient amount of paraffin and wax being thrown into warm

[1] *Dental Times*, July, 1864.

water, and an assistant aiding to keep the mixture at the proper temperature, the mode of procedure was as follows: A proper quantity of the compound was placed in the cup, introduced into the mouth, and pressed up firmly against the arch; the portion forced into the palatine fissure was at the same time pressed with the finger introduced through the nasal cavity, so that it should give an accurate impression of the region. A groove was then cut in this to serve as a key, and after oiling it a piece of the compound was introduced through the orifice of the nasal cavity, and passed down to make the impression of the floor of the nasal cavity. When sufficiently hard it was carefully removed, the upper surface trimmed, placed in cold water to secure its greatest firmness, then introduced into the cavity and pressed into its proper position. The metallic cap containing the impression of the palatine arch was then removed. The next step was to take an impression of the sides of the cavity, then the top, using a curved wooden spatula to press the compound in proper position, being careful to mark or key the parts that came in contact, and have their surfaces oiled to prevent adhesion, and also that the pieces should be thinner in front than in their posterior parts, so that when the four pieces forming the impression of the base, sides, and top were in their proper position, they would leave a tapering cavity with its largest diameter at the front orifice. Into this orifice was forced a plug or cone of the compound, filling it completely; in the front of this piece were inserted pieces of match-sticks to cause it

FIG. 1031.

Internal View of Superior Arch.

to adhere to the next piece or mask. The head was now thrown back to nearly a horizontal position, wet tissue-paper was placed over the eyebrows and lashes, the face oiled, and plaster mixed thick was batted on with a brush. When set, this was removed, drawing with it the central plug or cone; the different parts were then carefully removed, and thrown into cold water to give them a consistency that would bear

handling without danger of injury. On this central cone all the parts were placed in their proper position, and the impression of the palatine arch was adjusted in its proper place. From this a plaster model was made, giving the upper part of the face, cavities, palatine arch, all correctly in their relative positions.

"To prevent derangement it was necessary to make the appliance as simple as possible; it consisted of two pieces: the external nose, septum, and floor of the nasal cavity constituted one, having a projection passing downward into the palatine fissure, as represented in Figs. 1031 and 1032, A; and the other, the obturator B, Fig. 1033, with a projection rising upward into the palatine fissure. These projections were made

FIG. 1032.

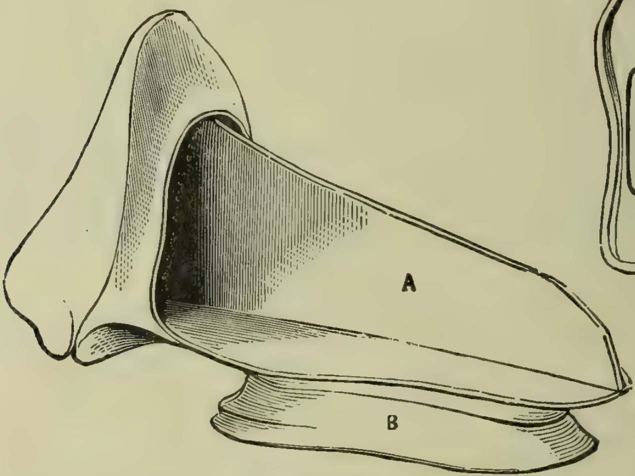


FIG. 1033.

Nose with Attachments.

hollow, so that when the two parts were placed together, as in Fig. 1032, there would be a cavity or box wherein the attachments could be placed.

"Models were made of the compound of paraffin and wax, which were strengthened in the weaker parts by imbedding small strips of metal in their substance to give sufficient firmness to admit of the necessary handling without injury. The combined parts were then applied to the patient, and the nose trimmed so as to harmonize with his features. These were next imbedded in plaster in the usual manner for vulcanite work, with the exception that a stout curved wire passed through the artificial nasal cavities, extending beyond their borders, to give strength to the rods of plaster forming these cavities in the matrix, and thus to prevent their fracture in packing.

"This appliance was vulcanized four hours, consuming one hour in attaining 280° F., at which point it was held one hour, and occupying the third hour in elevating the temperature to 320°, where it was retained one hour. The work was rather overdone, but not so much as to injure it.

"The two pieces were retained in position by a staple and slide-bolt. In the recess of the part of the floor of the nasal cavity projecting into the palatine fissure (A, Fig. 1032) was inserted a gold staple. In the recess of the projection of the obturator passing into the palatine fissure (B, Fig. 1033) were the gold catch and shield of the slide-bolt. The object of this shield was to prevent any foreign substances entering the slot and obstructing the movements of the bolt, also to give a base of support to the catch. The rectangular upright of the catch was soldered to the shield, passed through it and a longitudinal slot in B, and securely fastened to a rubber slide inlaid longitudinally and moving freely in the lingual surface of the obturator. On the anterior end of this slide was a small rounded projection, which enabled the patient, when the two parts of the appliance were placed in their proper position, with the point of a finger introduced into the mouth to force the slide backward, thereby to pass the catch into the staple and firmly secure the apparatus, or by drawing the slide forward detach the parts when desirable to remove them.

"The external nose was painted with an oil color, to give it as nearly a flesh tint as possible, although this is not wholly attainable upon an opaque ground. Flesh being translucent, a true imitation can only be made upon a translucent ground.

"The apparatus was introduced on June 30, 1863, giving to the patient great satisfaction and comfort. His appearance was much improved, as may be judged by comparing Figs. 1030 and 1034, which were engraved from photographs. He breathes freely through the nose, and speaks with ease; the only imperfection in his speech is a nasal twang, and this is less now than when the instrument was first applied. The obturator at first extended too far back, and caused some irritation of the velum; this defect was readily remedied.

FIG. 1034.

The Face with Nose.

"The operation proved entirely satisfactory, with two exceptions: first, the color of the nose was not as natural as desirable, for the reason already stated; second, in deglutition and speech, when the tongue pressed forcibly against the posterior part of the obturator, an unpleasant vibratory movement of the apex of the nose was noticeable. This could have been remedied by an elastic attachment coupling the two parts of the apparatus, but this mode was objec-

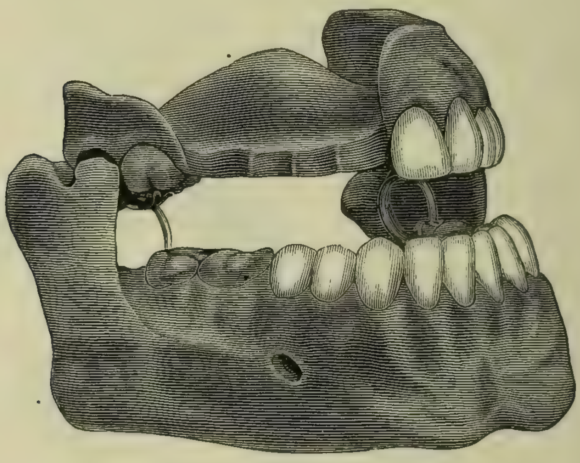
tionable by reason of its producing constant pressure upon the delicate parts, and thereby endangering absorption. A safer plan was adopted by inserting a small steel pin in the nose as near as possible to its apex, to which was attached the bridge of a pair of spectacle-frames, these being retained in position by an elastic cord attached to the bows and passing around the head. This arrangement answered the double purpose of counteracting the vibratory movement, and the bridge of the frames concealing the upper part of the joint where the nose came in contact with the face, which was most conspicuous.

"This apparatus is worn at the present date with ease and comfort by the patient."[1]

Cases of facial deformity, where the contour has been lost by removal of portions of either maxilla, are successfully treated by the use of "plumpers" attached to an artificial denture. The required symmetry having been obtained by a wax model, the piece is reproduced in vulcanite or any other desirable material.

Fig. 1035 shows a side view of an artificial jaw of vulcanite and

FIG. 1035.



partial upper plate combined, which was made to supply a deficiency necessitated by an operation for necrosis performed by Prof. W. Parker of New York. The upper and lower parts were connected by springs placed on each side of the ramus, and attached above to each heel of the plate. The appliance was made by Dr. G. Dieffenbach, who made the duplicate from which the above figure is drawn, and deposited it in the museum of the Pennsylvania College of Dental Surgery.

[1] During the session of 1879-80 this patient presented himself at the clinic of the Pennsylvania College of Dental Surgery for the replacement of the palatal portion of the appliance (Fig. 1033), which he had accidentally swallowed. The missing portion was replaced, and with a more secure form of attachment than that originally employed. The obturator which had been swallowed caused the patient considerable inconvenience and suffering during several weeks, but was finally safely discharged by way of the lower intestinal tract.

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